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HEALTH AND ANNOYANCE IMPACT OF ODOR POLLUTION

John R. Goldsmith

California State Department of Health

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16. ABSTRACT

Several studies were carried out on health and annoyance reactions to community odor from pulp mills and other industrial sources. Questionnaires were used to collect information from respondents on exposure to the odor and on health and annoyance reactions. The health reaction section of the questionnaire included a symptom check-list and the basic questions from the British Medical Research Council's (MRC) questionnaire on respiratory symptoms. Exposure to odor was also measured by dynamic olfactometry. In general, the frequency with which odor was noticed and the frequency and intensity with which respondents were bothered by the odor are correlated with odor intensity and frequency as measured by dynamic olfactometry within each community. It should, therefore, be possible to formulate a quantitative relationship between measurements of exposure to community odors and measurements of community reactions. Further refinement in methods and a larger number of observations representing a broader span of exposures are necessary to accomplish this.

In two communities only a few statistically significant differences in reported symptoms were found related to differences in exposure. In the third area, a greater number of such differences occurred. Symptoms showing significant differences by exposure in at least one study included dizziness, nausea, or vomiting; headache; runny nose; cough; sinus congestion; nose irritation; chest pain; and the MRC symptoms of persistent cough and/or phlegm and shortness of breath.

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by

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HEALTH AND ANNOYANCE IMPACT OF ODOR POLLUTION

SECTION I

I. Background

The first California study of community reactions to odors in the ambient air was undertaken with the encouragement and assistance of Dr. Erland Jonsson, a visiting Swedish sociologist who is an expert in the field of annoyance reactions to both odor and noise. The development of the annoyance questionnaire used in the first Eureka study was largely due to him and was modeled after a similar questionnaire used in a previous study conducted in Clarkston, Washington. The selection of Eureka as the initial study location was based on the obvious exposure to pulp mill odor as well as local interest and the numerous complaints received from the public concerning the odors.

SECTION II

II. Selection of Communities

As called for in the scope of work, three communities were chosen to represent health and annoyance reactions to exposure to odor from pulp mills and refineries. A fourth was chosen as the site of a pilot study of reactions of a community panel over a period of time. These are described briefly as follows:

A. Eureka: Eureka was chosen as the site of a second survey for several reasons:

1. Extensive evaluation of exposure and reactions to odor had been conducted in the previous survey and a second survey would permit evaluation of trends over time.

2. Only limited data on health had been obtained in the first survey. The second survey was planned to include collection of more extensive health data as well as information on background variables and annoyance reactions for comparison with the first survey.

B. Anderson: Anderson, located in the northern Sacramento Valley was chosen as one of the communities to represent exposure to pulp mill odors. Complaints concerning the odors had been received from citizens, and the Department's Air and Industrial Hygiene Laboratory was planning an evaluation of the environmental aspects of the odor problem under contract with the California Air Resources Board. These results would be available to us. The questionnaire used in Anderson was limited to health reactions, and data were collected both by personal interview and postal questionnaire, permitting an evaluation of results obtained by the two methods.

C. Carson: Carson, a community in the greater Los Angeles area, was chosen to represent exposure to refinery odor. However, the community is also exposed to odors from other industry, including other representatives of the petrochemical industry, and it was decided that no attempt would be made to distinguish reactions to the different odors. In addition, the community is exposed to general L.A. smog odors, including automobile exhaust. The questionnaire survey was similar to that used in the second Eureka survey and was designed to measure background variables, annoyance reactions and health effects.

D. Richmond: Richmond, a community located near refineries and with a history of odor complaints, was selected as the site of a study utilizing a panel of community members who were to report at specified times concerning their experience with odor in the community.

SECTION III

III. Methodology

A. Population Surveys

1. Selection of Exposure Areas Within Communities.

In general, if a point source of odor is identified and meteorologic data are available to indicate the probable course of atmospheric dispersion of odor, it is possible to identify locations in which odor exposures will differ in relation to a single source. This method has been used to select areas differing with respect to exposure throughout the studies to be reported here. In most cases, such allocations by area provided a presumptive gradient for odor exposure. Three areas were used in each of the communities. The day-to-day variation in odor exposure may be different from that which is presumed to occur as a result of location and meteorologic factors. For example, this could occur if the prevailing meteorologic patterns were not the patterns which were occurring during a specific hour, day or week. In every case, the choice of exposure area was made bearing in mind the need for comparability on other variables. These included basic geographic characteristics and economic status as indicated by visual inspection of housing. In addition, questions have been used in each survey in order to determine the demographic comparability of the areas, and the reports contain the results of this.

2. Pollution Measurements in the Ambient Air

Pollution measurements have been made as planned, but the measurable pollutants are not in general the odorants to which the subjects are presumed to be responding. Tabulation of these measurements in detail are available for inspection. In general, however, the measurement of such pollutants as methylmercaptan, specific hydrocarbons, or hydrogen sulfide has not been systematically possible because the concentrations of these odorants which produce annoyance and other reactions were substantially lower than the level detectable using the available monitoring equipment. The possible exception to this is hydrogen sulfide, which was not a prominent pollutant in any of these studies. However, efforts were made in the first Eureka study to make such measurements and these data are available. Pollutants measured in each study are indicated on Table 1.

3. Stack Measurement and Exposure Estimate Based on Diffusion Modeling.

In the first Eureka study and in the follow-up study, stack sampling was carried out, and estimates from these measurements can be used to determine whether the point source emits comparable levels of pollution on the days in which comparisons are made.

4. Dynamic Olfactometry.

Dynamic olfactometry was carried out in all studies except that in the Richmond area. Dynamic olfactometry equipment was improved during the work on this project, and the technique and design of the equipment was modified. Dynamic olfactometry uses a panel of trained laboratory workers whose odor threshold is determined twice a day and who are asked to determine whether odor is present in the ambient air and how much dilution of this air is required for the odor to disappear. The time periods represented are indicated in Table 1.

5. Population Sampling.

Population sampling followed the same pattern in all three communities, consisting essentially of systematic sampling of households with random starts in the various subareas of each community. In Eureka, the samples for the two surveys were chosen so as to be mutually exclusive. In Anderson, a similar procedure was followed for the postal and personal interview surveys.

6. Questionnaire - Annoyance and Health Reactions.

Several different questionnaires were used in the community study. The major sections dealt with background variables which might affect responses to the questions, perception of the exposure situation, annoyance reactions, implications of the annoyance reactions and health effects. The health effects section included selected questions from the British questionnaire on respiratory symptoms as well as questions concerning a list of symptoms. Questionnaires used in each survey are appended, and the individual reports describe their content in detail. They were administered by personal interview except for the postal survey conducted in Anderson. The differences are summarized below as well as on Table 1.

a. Eureka

The questionnaire used in the first Eureka study included questions on background variables and annoyance reactions and was administered by interview. The only health questions referred to symptoms which the respondent attributed to the odor and were asked only of those who had already indicated that they were very much or moderately bothered by the odor. The second Eureka study included the same questions as the first concerning background variables and annoyance reactions in order to provide data to evaluate changes during the two-year period between the two studies. It also included an expanded health section consisting of questions concerning a list of symptoms as well as selected questions concerning respiratory symptoms. The health questions were asked of all respondents and were placed after the questions on background variables and annoyance reactions in order to prevent biasing the annoyance reactions which were to be used for comparison with the previous survey. However, this could have resulted in bias in responses to the health questions. In an attempt to prevent this, the health questions were introduced simply as a health survey, not bearing any relationship to the annoyance questionnaire, and the design of the annoyance questionnaire itself was worded so as not to draw attention to pulp mill odors as the area of primary interest.

b. Anderson

The Anderson questionnaire consisted only of the health section of the second Eureka questionnaire to avoid interaction with the annoyance section. To provide comparative information on results obtained by personal interview and postal questionnaire, two separate surveys were conducted. The questionnaires used in both were designed to be as nearly alike as possible.

c. Carson

The Carson questionnaire was essentially the same as that used in the second Eureka survey with the modifications necessary to relate it to general industrial odor in contrast to pulp mill odor. These modifications consisted principally of the deletion of questions which related specifically to pulp mill odor and which permitted distinguishing responses in the Eureka survey described as "probed" from those described as "semi-probed". The questionnaire asked for information concerning background variables, annoyance reactions and health.

B. Community Panel Survey

The work of Richmond represents primarily a feasibility study of the use of a panel of community members to report at specific times concerning the presence of odor in the community, its intensity, disagreeableness and possible source. Report forms were collected and edited by local supervisors and submitted for tabulation. As in the other studies, three areas of the community were chosen to represent presumptive differences in exposure to the odor.

SECTION IV

IV. Results - Summary

A. Introduction

Differences in the type of exposure to odor, background characteristics of respondents, and methodology in the various studies limit the possibility for comparisons between the communities. Attention should be concentrated on comparisons among the exposure areas within each community, the relationships between the various methods employed, and the patterns of response found within each community. Several factors should be kept in mind.

1. Apparent differences over time in the two Eureka studies may reflect differences in public response to a fixed problem as well as differences in exposure to odor. Furthermore, the latter could be a function of differences in weather conditions as well as of differences in emissions from the mills. A comparison of the two Eureka studies is presented in the attached

report, "Trends in Community Annoyance Reactions to Odors from Pulp Mills".

2. Differences in results from the two communites exposed to pulp mill odors (Eureka and Anderson) may be affected by the following factors as well as by differences in emissions:

    a. Proximity of the study areas to the mills.
    b. Climate.
    c. Topography.
    d. Sensitivity of the population samples to the odor and dependence of the members of the community on the mills for economic survival.
    e. Methodological differences which might have occurred, although every effort was made to use comparable methods.

3. The comparisons of the results of postal survey with the results of personal interview in the same community are the subject of the attached report, "A Comparison of Postal Questionnaires and Personal Interviews in Estimating the Frequencies with which Symptoms are Reported in Residential Areas Exposed to Pulp Mill Odors".

4. Emissions from the pulp mills in Eureka and Anderson represent essentially point sources while emissions from the refineries and other industries in Carson represent a diffuse source further compounded by exposure to odors from automobile exhaust and general L.A. smog.

B. Population Surveys

1. Dynamic Olfactometry

Dynamic olfactometry appeared to work well in establishing differences of exposure to odor in two of the three communities in which it was used. The exception was Carson, which represents a diffuse source of odor distributed among several industries in contrast to the point sources which are represented by Eureka and Anderson. In addition, Carson has a background odor from general Los Angeles smog.

2. Annoyance Reactions

In general, the frequency with which odor was noticed and the frequency and intensity with which respondents were bothered by the odor follow the odor exposure gradients as defined by presumptive exposure and by dynamic olfactometry in each community.

3. Health Effects

In Eureka and Carson few significant differences in health effects were found related to differences in exposure by area. In Anderson a greater number of such differences occurred. Symptoms showing significant area differences in at least one study include constipation; dizziness, nausea, or vomiting; headache; runny nose; cough; sinus congestion; irritation of the nose; chest pain; and the MRC symptoms of persistent cough and/or phlegm and shortness of breath. Hence the frequency of positive responses to the "dummy" question on constipation followed the same trend as the others. The greater frequency with which many symptoms were reported by women indicates the importance of adjusting for sex in the analysis.

Symptoms showing a relationship to the amount by which the respondents were bothered by the odor regardless of the exposure area in which they live include the following: headache; dizziness, nausea, or vomiting; eye irritation; and burning or irritation of the nose.

4. Measurements of Particulates

Although some particulates showed significant statistical differences in concentration by subareas within communities for same quarters of the year, the magnitude and consistency of these differences do not appear sufficient to have produced the health effects that occurred. This is discussed more thoroughly and the data are presented in the attached report, "Evaluation of Area Differences in Exposure to Total Particulates, SO_4, and NO_3 in Each Community Studied".

SECTION V

V. Evaluation and Recommendations

A. Evaluation

1. On the basis of our experience, we believe that odor monitoring can be based on community panel responses with dynamic olfactometry follow-up, at least in the case where a single source of repetitive pollution is likely to be causing the odor. The evaluation of dynamic olfactometry in multiple source problems is not complete.

2. We believe that there is suggestive evidence that health reactions above and beyond the annoyance reactions to odor are occurring, but the present studies have not been capable of elucidating these reactions. Although evidence is not convincing, we suggest that the most likely effects apart from annoyance due to community odor exposure are changes in ventilatory function of the lung, changes in secretions of the respiratory tract, changes in gastrointestinal function, the occurrence of gastrointestinal and respiratory symptoms, and headache.

3. Our studies have not dealt with the possible psychiatric or psychosocial aspects of odor exposure, nor have they evaluated the possible interference of odor exposure with defensive or adaptive reactions.

B. Recommendations

Further research in seeking to establish air quality criteria for odorous materials, and control principles based on them, should be focused in the following areas:

1. The development of prototypical dynamic olfactometry and panel monitoring systems, combined with stack sampling or community annoyance surveys should be carried out. The application by air pollution districts of such systems should be encouraged and they should be asked to participate in further studies of such methods.

2. The better delineation of practical procedures for odor threshold determination and its application to dynamic olfactometry should be carried out by laboratory studies, and prototypical methods for determining odor thresholds in community samples should be developed as a parallel activity.

3. Studies of physiological reactions to experimental exposures to odorants at levels, and of a type, common in community air pollution should be carried out.

Table 1

DATA OBTAINED IN COMMUNITY ODOR STUDIES

Measurement	LOCATION				
			Anderson		
	Eureka I	Eureka II	Personal Interview	Postal Questionnaire	Carson
Type of Odor					
Pulp Mill	X	X	X	X	
Other (including refineries)					X
Questionnaire					
Month/Year	8/69	8/71	11/70	4-6/71	3-4/72
Background Data	X	X	X	X	X
Annoyance Reactions	X	X			X
Health Survey		X	X	X	X
Dynamic Olfactometry	6-8/69	9/71	8/70		3/72
Hi Vol Particulates*					
Total Particulates		1-4	1-4		2-3
SO_4		1-4	1-4		2-4
NO_3		1-4	1-4		2-4
Organics		1-4	1-4		2-4
Ambient Gases					
Oxidant		1-4	1-4		2-4
SO_2		1			2-4
NO_x			1-4		2-4
NO_2		1-4			
Total Reduced Sulfur		1			

Number indicates quarters as follows:
1 July–September, 1971
October–December, 1971
January–March, 1972
4 April–June, 1972

SECTION VI-A

COMMUNITY REACTIONS TO ODORS FROM PULP MILLS
A PILOT STUDY IN EUREKA, CALIFORNIA

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Bureau of Occupational Health and Environmental Epidemiology
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California State Department of Public Health

Based on a report presented at
the Conference on the Measurement and Evaluation of Odor
in the Community in Relation to Odor Sources.

Stockholm, Sweden, June 1970

Supported in part by a contract with National Air Pollution Control Administration.

INTRODUCTION

Odor in the air has been the basis for many general complaints about air pollution.[1] Indeed, for many persons air pollution is considered to be mainly a problem of odor.[2] In spite of this, the subject has had little scientific attention. However, several recent studies, made specifically of community reactions to odor from industries have given information on the presence of annoyance reactions and symptoms such as nausea and respiratory complaints in the exposed populations.[3] In several instances this information has been of practical use in deciding whether action should be taken to control the odor in a community.[4] Although some of these studies have compared community reactions in areas in which different exposures to the sources of the odors were assumed,[3,4,5] no studies known to the authors have compared quantitative odor exposure data to community reaction data.

The main purpose of the study reported here was to determine whether it is possible to demonstrate the relationship between quantitative data describing exposure and quantitative data describing community reactions. Eureka, which was chosen as a suitable community for this study, is a coastal city in northern California with a population of about 30,000, located in an area in which the lumber industries play a major part in the economy. Two pulp mills were recently built on a peninsula to the west of the community. During part of the year, offshore winds carry odorous materials from the pulp mills inland across Humboldt Bay to residential and business areas of the city.

METHODOLOGY AND MATERIALS

Sampling. Three residential areas were chosen that were presumed to have different exposures to the odors on the basis of location with respect to the mills and prevailing offshore winds. Area I is situated 1-2 miles southeast of the mills and is expected to be more frequently exposed to emissions from the pulp mills than the other two areas. Area II is located 2-3 miles east of the mills and is assumed to be exposed to the odor less frequently, while Area III, with the least exposure, is located approximately 4 miles east of the mills. The relative location of the pulp mills and the three areas is shown in Figure 1.

Between 55 and 60 households were chosen in each of the areas by systematic random sampling. The proportions of total households represented by the samples in each area were as follows: Area I, about one-fifth; Area II, about one-third; and Area III, about one-half. The initial samples were designed to include approximately equal numbers of men and women. It was determined randomly whether a man or a woman (usually the head of household or his wife) was to be interviewed in each household, but if an adult of the designated sex was not living in the household, any adult living there was interviewed. Because of the sample design and the population structure of the areas surveyed, more women than men were represented among the respondents.

The sample sizes, the distribution by sex, and the proportion of interviews successfully completed are shown in Table 1. The original samples were augmented to replace unoccupied houses; the numbers described as ''sample'' include these additional households and represent the total numbers of houses approached. The nonrespondents represent a total of six households in which the respondent refused to be interviewed after at least two visits and, in addition, two households in which it was not possible to contact the respondent after repeated visits. Based on occupied households in the sample, an overall response rate of 95.2% was obtained.

Exposure Data. The exposure to odor in the three areas was estimated by dynamic olfactometry. The measurements are based on the ''odor dilution factor,'' which is the ratio of ambient air (air to which the community is exposed) to odorless air at which a trained observer just detects malodor. This is converted to the equivalent of parts per billion of a specific odorant by multiplying by the odor threshold of each observer, which is the ratio of a known dilution of a specific odorant to odorless air at which the observer just detects the malodor.

The sensitivity of the method is a function of the observer's odor threshold and the lowest dilution of odorant to odorless air that can be measured on the olfactometer. In order to sample the ambient air adequately, daily observations were obtained during three two-week periods in June, July, and August. Two observers were exposed to the ambient air at several sites in each of the three areas at half-hourly intervals during the day. The sampling sites, the method of sampling the ambient air, and the instrumentation and technique of using the olfactometer are described in detail elsewhere.[6] The odor threshold of each observer was measured twice a day.

Questionnaire and Interviewing. The questionnaire consists of five major sections. (Appendix 1.) The first section deals with such background data as age, occupation and family structure; the second section with satisfaction with general conditions in the residential area and the community; and the third section with air pollution and noise problems in the residential area. The questions of greatest interest in the study occur in the fourth section, which deals specifically with the effects of odors from pulp mills. The fifth section of the questionnaire consists of questions designed to measure attitudes toward pollution and noise problems in general. The questionnaire was pretested in a town close to Eureka which has occasional exposure to pulp mill odors. The average time required for interviewing was between fifteen and twenty minutes.

The interviewing was carried out during the last two weeks of August, 1969. About two-thirds of the interviews were completed during the first three days of the study, using six interviewers who continued to work throughout the first week. One interviewer continued working during the second week and did additional follow-up interviewing about a month later. A training period of two to three days at the beginning of the field work included detailed explanation and discussion of each item in the questionnaire and the method of recording responses, as well as practice in using the questionnaire by means of role playing. The practice interviews were recorded on tape and replayed for correction of errors and discussion of interviewing technique. This was followed by actual practice field interviews in an area which was not to be included in the survey. The practice interviews were edited for omissions, inconsistencies, and errors in recording responses, and any problems were discussed with the interviewers. Similar editing was done during the survey itself so that errors could be corrected while the field work was still in progress and interviewer performance could be evaluated and modified if necessary.

The interview was introduced to the respondents as part of a survey on how people feel about the community in which they live. In order to mask the principal aim of the study, no mention was made of health or of odor from the pulp mills. This has been found in previous studies to be important in obtaining unbiased results.[7]

RESULTS OF ANNOYANCE SURVEY

The results presented here fall into four main groups:

1. Perception of the exposure situation.
2. Annoyance reactions.
3. Implications of the annoyance reactions.
4. Relevance of the background variables to annoyance reactions.

Detailed descriptions of the responses tabulated on each table are given in Appendix 2.

1. Perception of the Exposure Situation

The frequencies with which the odor is noticed in the three areas are shown in Table 2. These are tabulated from responses to questions asking whether the respondent has noticed the odor from pulp mills during the last three months, and, if so, how often it was noticed. Obvious differences occur between the three areas with respect to how often the respondents notice the pulp mill odors. In Area 1, 23% of the respondents said that they noticed the odors every day. In Area II, the corresponding frequency was 13%. In the third area no respondents reported that they noticed the odor daily. The odor was noticed at least once a week (including ''every day'') by about 81% of the respondents in Area I, about 55% in Area II, and 12% in Area III. These differences are statistically significant at the 5% level using a χ^2 test for trend. Some persons said they did not notice the odor at all; this response was given by 6% in Area 1, 20% in Area II, and 35% in Area III.

2. Annoyance Reactions

The data presented in Table 3 are tabulated from a question allowing six alternative responses indicating how much the odor has bothered the respondent. Half of the respondents in Area I were very much or moderately bothered. This response was also given by 31% in Area II, and 18%

in Area III. The response ''not noticed or not bothered at all'' was given by 27% in Area I, 45% in Area II, and 65% in Area III. These differences also resulted in a significant χ^2 for trend.

Respondents who were bothered were also asked how often they were bothered. These data are presented in Table 4. In Area I, 9 out of 26 who were very much or moderately bothered were bothered at least several times a week; in Area II, 5 out of 17 gave these responses; but in Area III, none of the 9 respondents in this group said they were bothered as often as several times a week.

People who reported being very much or moderately bothered were asked whether they thought the situation with regard to pulp mill odor was better or worse compared with the previous summer. As shown in Table 5, about half of the individuals who were very much or moderately bothered thought that no change had occurred since last summer, or answered ''don't know.'' Of the 23 respondents who thought there had been a change, 18 thought that conditions were better; 13 of these thought it was because there was actually less odor, while 5 thought it was because they had grown used to it. Five persons thought the odor situation was worse this summer than last summer.

3. Implications of the Annoyance Reactions

The implications of the annoyance reactions were studied by examining the relationship between questions about symptoms and annoyance reactions, and also by measuring the degree of spontaneity with which the odor was mentioned and how likely the respondent was to try to change his exposure to the odor. Among the 31 respondents who were very much bothered, only 1 person said that he did not get any of the symptoms on the list when he was bothered by the odor. Somewhat more than half of the respondents who were moderately bothered were without such symptoms.

About 25% of all respondents said they had experienced one or more symptoms in connection with pulp mill odors. Nausea and sinus congestion were reported by about 15% each, and eye irritation and headache by about 10% each. Other respiratory symptoms such as cough and shortness of breath, and nasal symptoms such as nose irritation and runny nose were reported by 5-10% each. These data are summarized in Table 6.

Respondents were given an opportunity to mention the pulp mill odor problem in response to questions that did not deal specifically with air pollution (spontaneously); in response to questions about odor from industries but with no specific mention made of pulp mills (semi-probed mention of pulp mill odor); or in answer to specific questions about pulp mill odor (probed mention of pulp mill odor), as shown in Table 7. These categories are considered to indicate the saliency of the problem to the respondent. In Area I, about 50% spontaneously mentioned the problem of odor from pulp mills; in Area II, about 20%; and in Area III, only 4% (2 individuals). Of 40 individuals who mentioned odor spontaneously, 29 were very much or moderately bothered. Two-thirds of these individuals lived in Area I. Only 7 persons who mentioned odor from the pulp mills did not mention it until they were specifically asked about it, and only 1 of these said he was very much or moderately bothered by the odor.

The respondents were asked whether they had ever thought of requesting or had actually requested some authority or agency to take action concerning the pulp mill odor. In addition, positive responses to an open-ended question as to whether they had felt like moving away from the community were coded according to the reason given. Individuals who gave pulp mill odors as the reason are included with those who had ''thought of taking action'' in Table 8. The table shows that action was taken by only one person who was not very much or moderately bothered by the odor, and that of those who were very much or moderately bothered, respondents in Area I were more likely to take action than those in the other areas. The ''action'' dimension is regarded here as a measure of the respondent's tolerance toward the problem.

4. Relevance of the Background Variables to Annoyance Reactions

A number of questions were included in the interview primarily to provide information on variables which might differ among the three areas and at the same time be related to annoyance reactions. To test the possible effect of these variables, two-by-two tables were constructed comparing responses on each of the variables with the degree to which the respondent was bothered by pulp mill odors, and χ^2 tests with one degree of freedom were carried out. Detailed descriptions of the variables can be found by referring to the questionnaire and Appendix 2. As can be seen in Table 9, significant χ^2's (starred) were obtained for seven of the seventeen background variables. All but age, household structure, and housing index could obviously be a result of, as well as a causative factor in, annoyance.

In order to determine whether the relationship between annoyance reactions and these background variables might account for the area differences, the proportions very much or moderately annoyed in each area were compared within each of the two strata of each background variable. (See Table 10.)

Since a larger proportion of respondents was very much or moderately bothered in the under 50 age group than in the 50 or over age group, the larger proportion of young adults living in Area I than in Area II could account for some of the area differences. However, as shown in Table 10, the area gradient in percent very much or moderately bothered occurs within the younger age group. A similar result is seen for household structure. A larger proportion of respondents in households with children is very much or moderately bothered by the odor. However, the area gradient is maintained within this stratum.

RESULTS OF EXPOSURE MEASUREMENTS

Complete results of the exposure measurements made by dynamic olfactometry are presented in a separate report.[6] The discussion here is limited to a summary of the most important results relevant to evaluation of the annoyance reactions. Comparison of results for the three areas shows that Area I has the greatest exposure to odor, Area III has the least exposure, and Area II has an intermediate exposure, regardless of which of three indices of exposure is used. This is demonstrated in Tables 11, 12, and 13 which show, respectively, the percent of total observations which indicated detection of odor, the diurnal malodor concentration at 92nd percentile and the maximum malodor concentration detected. These results agree with the presumed exposure of the areas to pulp mill odor as well as with the annoyance reactions of the residents of each area.

DISCUSSION

It has been shown in studies of community reactions to air pollution and noise that if the respondents are aware of the real purpose of the survey they may tend to exaggerate annoyance reactions in an attempt to force community action to reduce the environmental irritant.[7] To avoid this, the purpose of the study was masked, the field work was accomplished in as short a time as possible to reduce the possibility of discussion of the study among respondents, and no publicity was given to the study through mass media.

The method of measuring exposure does not exclude the possibility of an expectation effect. The members of the odor panel knew in which study area they were making each measurement, and, in some cases, were able to smell the odor before they were exposed to the sample of ambient air being passed through the instrument panel. It is improbable that such an effect was great enough to invalidate the measurements.

The population samples used for the study are not representative of the general population. Thus, statistically valid community-wide estimations of annoyance reactions cannot be made from the results reported here. However, the results do strongly suggest that many people, especially in Area 1, are very concerned about the odor problem and that some of them attribute to the odor symptoms such as nausea, sinus congestion, and eye irritation, which may or may not be largely psychosomatic.

Neither the method used for exposure measurements nor the method used for annoyance reactions is at present as precise as one would like. In spite of this, and in spite of the fact that only three areas were used for the study, the results show clearly that there is an association between the exposure data and the reaction data.

An analysis of the implications of the annoyance reactions suggests that it should be possible to construct a reaction index for further studies by using, besides the annoyance questions, information about presence of symptoms, how spontaneously the respondent mentions the environmental irritant, and how willing the respondent is to take action to force a change.

Of the background variables, those measuring attitude appeared to be of the greatest relevance in determining the degree of annoyance reaction. These included general attitude toward odor, attitude toward pulp mills, estimation of the odor problem in Eureka, action to change other conditions, attitude toward authorities, and concern about other community problems. These relationships may be an indication that the attitudes resulted partly from the reactions to the exposure rather than that they were a determining factor. However, it should be noticed that about 60% of the respondents who were very much or moderately bothered said that they thought the pulp mills were good for Eureka.

The results of this study indicate that it should be possible to formulate a quantitative relationship between measurements of exposure to pulp mill odors and community reactions. Further refinement in methods and a larger number of observations representing a broader span of exposures are needed.

Table 1

DESCRIPTION OF THE POPULATION SAMPLES

Eureka, 1969

RESPONSE	I			II			III		
CATEGORY	Total	Male	Female	Total	Male	Female	Total	Male	Female
Sample Size	59	26	33	59	24	35	56	28	28
Respondents	52	22	30	55	23	32	51	25	26
Nonrespondents	3	1	2	4	1	3	1	1	0
Refusals	1	0	1	4	1	3	1	1	0
Not reached	2	1	1	0	0	0	0	0	0
Dwelling Unit Unoccupied	4	3	1	0	0	0	4	2	2

Table 2

FREQUENCY WITH WHICH PULP MILL ODOR NOTICED

Eureka, 1969

HOW OFTEN NOTICED	I	II	III
Total	52	55	51
Every day	12	7	0
At least once a week	30	23	6
At least once a month	5	7	15
Less often or don't know	2	7	12
Not noticed at all	3	11	18

Testing ''every day'' and ''at least once a week'' against other categories:

	χ^2	d.f.
χ^2 for trend	49.0**	1
χ^2 for departure from trend	0.6	1
χ^2 total	49.6**	2

** Significant at the 1% level.

Table 3

EXTENT TO WHICH BOTHERED BY PULP MILL ODOR

Eureka, 1969

AMOUNT BOTHERED	I	II	III
Total	52	55	51
Odor noticed	49	44	33
Very much bothered	15	13	3
Moderately bothered	11	4	6
A little bothered	12	13	9
Not at all bothered or don't know	11	14	15
Odor not noticed or don't know	3	11	18

Testing ''very much'' and ''moderately'' bothered against other.

	χ^2	d.f.
χ^2 for trend	12.2**	1
χ^2 for departure from trend	0.2	1
χ^2 total	12.4**	2

** Significant at the 1% level.

Table 4

FREQUENCY WITH WHICH BOTHERED BY PULP MILL ODOR

Eureka, 1969

HOW OFTEN BOTHERED	I	II	III
Total	52	55	51
Very much or moderately bothered	26	17	9
Often	9	5	0
Occasionally	16	11	2
Seldom	1	1	7
Only a little, or not bothered at all	26	38	42

Table 5

ESTIMATION OF CHANGE IN PULP MILL ODOR SINCE PREVIOUS SUMMER

Eureka, 1969

ESTIMATION OF CHANGE	I	II	III
Total	52	55	51
Very much or moderately bothered	26	17	9
No change or don't know[1]	11	12	6
Better - less odor	9	2	2
- used to it	4	0	1
Worse - more odor	2	2	0
- more sensitive	0	1	0
Only a little or not bothered at all, odor not noticed, or don't know	26	38	42

[1] Includes those who thought there was some change but did not know whether it was due to change in odor or in their sensitivity to it.

Table 6

FREQUENCY WITH WHICH SYMPTOMS WERE REPORTED WHEN BOTHERED BY PULP MILL ODOR

Eureka, 1969

NAUSEA	16%
SINUS CONGESTION	15%
HEADACHE	12%
EYE IRRITATION	10%
COUGH NERVOUSNESS NOSE IRRITATION RUNNY NOSE	5 - 9% each
SHORTNESS OF BREATH FATIGUE INSOMNIA CHEST PAIN PALPITATION VOMITING SWEATING	1 - 4% each

Table 7

SPONTANEITY OF MENTION OF PULP MILL ODOR BY EXTENT TO WHICH BOTHERED

MENTION OF PULP MILL ODOR	AREA I		AREA II		AREA III	
	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered
Total	26	26	17	38	9	42
Spontaneous mention of pulp mill odor	20	7	8	3	1	1
Semi-probed mention of pulp mill odor	6	16	9	21	7	21
Probed mention of pulp mill odor	0	1	0	3	1	2
No mention of pulp mill odor	0	2	0	11	0	18

Table 8

ACTION BY EXTENT TO WHICH BOTHERED BY PULP MILL ODOR

ACTION	AREA I		AREA II		AREA III	
	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered
Total	26	26	17	38	9	42
Took action	16	1	5	0	3	0
Thought of taking action	1	0	1	0	1	0
No action	9	25	11	38	5	42

Table 9

χ^2 TESTS OF BACKGROUND VARIABLES
(One degree of freedom)

Eureka, 1969

VARIABLE	VERY MUCH/ MODERATELY BOTHERED	OTHER	χ^2
Sex			
Male	18	51	2.06
Female	34	55	
Age			
< 50 years	41	53	10.88**
≥ 50 years	11	53	
Marital status			
Married	44	83	0.53
Other	8	23	
Occupation			
White collar	16	44	1.28
Other (blue collar and professional)	36	62	
Job associated with mills (respondent or spouse)			
Yes	3	5	0.01
No	49	101	
General attitude toward odor			
Annoyed	45	33	40.66**
Not annoyed	7	73	
Attitude toward pulp mills			
Good	32	97	18.96**
Bad	20	9	
General attitude toward noise			
Annoyed	20	36	0.14
Not annoyed	32	70	
Estimation of odor problem in Eureka			
Greater than other cities its size	27	11	30.73**
Other	25	95	
Estimation of noise problem in Eureka			
Less than other cities its size	21	35	0.54
Other	31	71	
Attitude of authorities toward air pollution			
Too little concern	35	25	26.49**
Other	17	81	

** Significant at the 1% level.

Table 9 (continued)

VARIABLE	VERY MUCH/ MODERATELY BOTHERED	OTHER	χ^2
Household structure			
Adults only	19	62	5.88*
Children	33	44	
Satisfaction with community			
Things other than pulp mill odor don't like	20	43	0.01
Other	32	63	
Housing index			
1-2	19	64	7.02**
3-5	33	42	
Concern about other community problems			
At least one other problem rated serious/somewhat serious	14	21	0.65
Other	38	85	
Exposure (hours/day)			
Six hours or less	29	58	0.00
Other	23	48	
How long in area			
Same residential area before mills	36	74	0.01
Other	16	32	

* Significant at the 5% level.
** Significant at the 1% level.

Table 10

PROPORTION OF RESPONDENTS VERY MUCH OR MODERATELY BOTHERED IN EACH AREA
WITHIN STRATA OF VARIABLES SHOWING SIGNIFICANT χ^2 VALUES

Eureka, 1969

	I		II		III	
	Number of Respondents	Percent Very Much or Moderately Bothered	Number of Respondents	Percent Very Much or Moderately Bothered	Number of Respondents	Percent Very Much or Moderately Bothered
Age						
< 50 years	37	64.9	28	39.3	29	20.7
≥ 50 years	15	13.3	27	22.2	22	13.6
General attitude toward odor						
Annoyed	27	74.1	29	58.6	22	36.4
Not Annoyed	25	24.0	26	0.0	29	3.4
Attitude toward pulp mills						
Good	42	42.9	42	16.7	45	15.6
Bad	10	80.0	13	76.9	6	33.3
Attitude of authorities toward air pollution						
Too little concern	23	78.3	21	61.9	16	25.0
Other	29	27.6	34	11.8	35	14.3
Estimation of odor problem						
Greater than other cities	15	80.0	13	84.6	10	40.0
Other	37	37.8	42	14.3	41	12.2
Household structure						
Adults only	18	16.7	36	30.6	25	20.0
Children	34	67.6	19	31.6	26	15.4

Table 11

PERCENT MEASURABLE ODOR DETECTIONS

(Odor Frequency)
Eureka, 1969

TIME OF DAY	AREA I		AREA II		AREA III	
	Total Number of Observations	Percent of Observations With Odor	Total Number of Observations	Percent of Observations With Odor	Total Number of Observations	Percent of Observations With Odor
Total 0800-1630	564	37.4	846	14.1	1128	5.9
0800-1130	256	23.4	384	13.5	512	3.5
1200-1630	308	49.0	462	14.5	616	8.0

Table 12

DIURNAL MALODOR CONCENTRATION AT 95th PERCENTILE
BY AREA AND TIME
(as ppb CH_3SH)

Eureka, 1969

TIME OF DAY	AREA I	AREA II	AREA III
0800	5.9	7.2	N.D.
0830	5.9	1.0	N.D.
0900	3.1	16.9	N.D.
0930	6.5	1.9	N.D.
1000	7.6	N.D.	N.D.
1030	3.6	17.6	[illegible]
1100	15.1	3.9	[illegible]
1130	4.1	10.4	3.8
1200	4.1	8.4	1.1
1230	16.9	2.4	2.6
1300	5.0	2.8	2.6
1330	18.0	21.1	N.D.
1400	12.3	2.6	N.D.
1430	21.2	N.D.	8.0
1500	17.1	9.0	N.D.
1530	9.5	N.D.	N.D.
1600	9.7	N.D.	7.3
1630	30.1	5.7	N.D.

N.D. = none detected, essentially 0.

Table 13

MAXIMUM MALODOR CONCENTRATION DETECTED*
BY AREA AND TIME
(as ppb CH_3SH)

Eureka, 1969

SAMPLING INTERVAL BEGUN AT	AREA I	AREA II	AREA III
0800	8.9	4.4	N.D.
0830	12.9	2.4	5.1
0900	11.4	28.2	N.D.
0930	52.5	3.8	N.D.
1000	59.2	N.D.	N.D.
1030	6.4	38.9	3.2
1100	24.7	5.5	2.4
1130	5.6	16.5	5.6
1200	10.1	31.2	1.4
1230	38.6	2.9	6.0
1300	33.3	5.0	7.1
1330	19.7	170.7	1.4
1400	28.1	23.9	N.D.
1430	249.6	0.9	21.9
1500	47.1	12.6	1.6
1530	16.6	1.2	N.D.
1600	26.0	N.D.	23.1
1630	239.4	16.1	N.D.

* In each case the concentration ranged from none detected to the maximum shown.

N.D. = none detected which means less than 2 x minimum O.T. of the the observer - essentially 0.

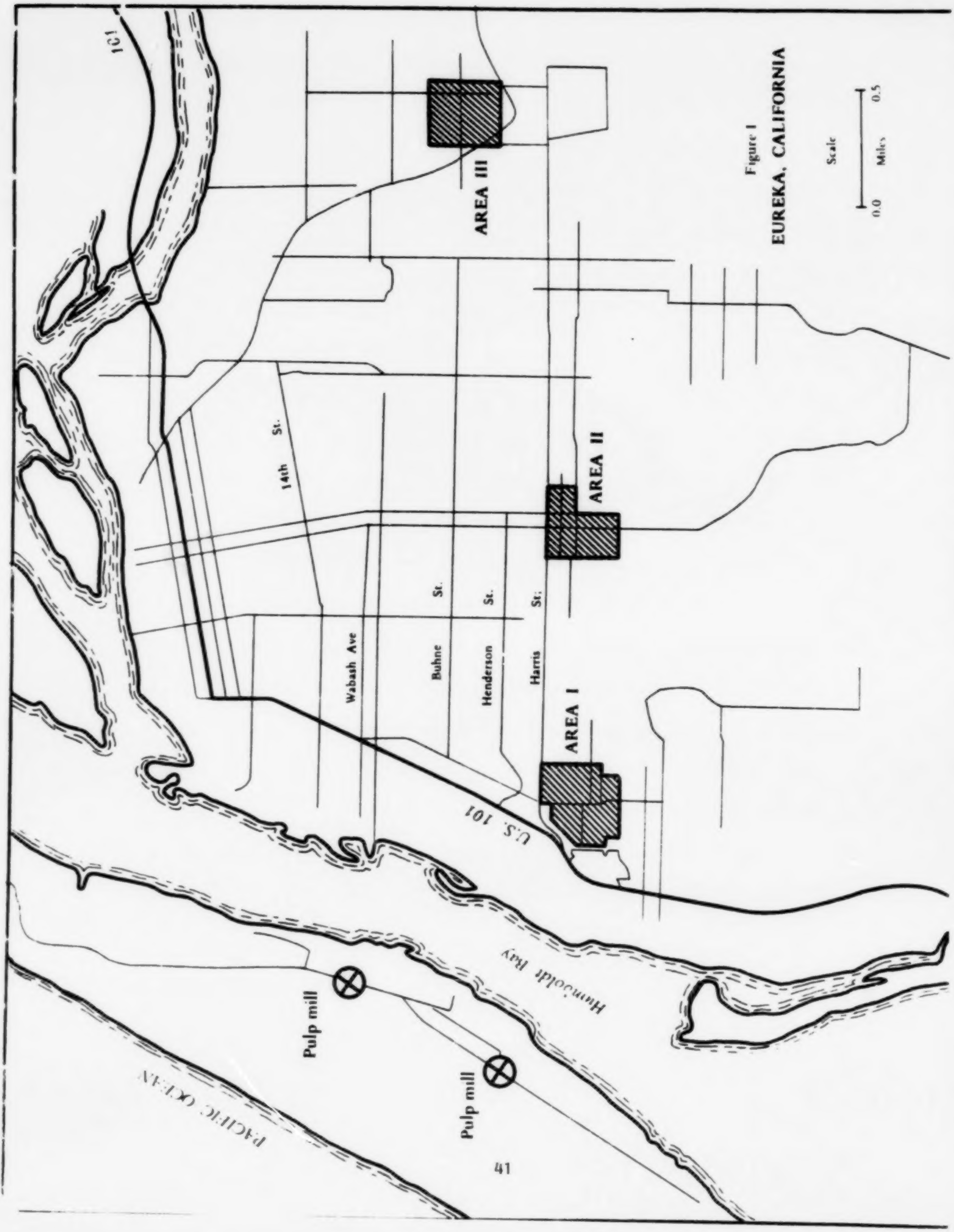
101
AREA III
AREA II
AREA I
14th St.
Wabash Ave
Buhne St.
Henderson St.
Harris St.
U.S. 101
Humboldt Bay
Pulp mill
Pulp mill
PACIFIC OCEAN
Scale
0.0
0.5
Miles

Figure 1
EUREKA, CALIFORNIA

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APPENDIX 1

See Section VII - Questionnaires

EUREKA PULP MILL STUDY

APPENDIX 2

Definitions of Analytic and Background Variables

Table 2

Positive responses to two questions were used to measure the frequency with which pulp mill odor was noticed by the respondent:

A. ''Have you noticed odors from industries here at home during the last three months? What industries?'' (Pulp mills were not specifically mentioned to the respondent. See page 10 of the questionnaire.)

B. ''Some people here in Eureka have been complaining about odors from the pulp mills. Here in your house have you noticed the odors during the last three months?'' (This question was asked only of respondents who had not already mentioned pulp mill to the question concerning odors from industry. See page 12 of the questionnaire.)

For each question, respondents who gave a positive response were asked:

C. ''How often? Is it every day, at least once a week, at least once a month, or less often?'' The ''not noticed at all'' category included individuals who did not know whether they had noticed the pulp mill odor. (See pages 10 and 12 of the questionnaire.)

Table 3

Individuals who had given positive answers to either questions A or B (above) were classified according to the extent bothered by pulp mill odor according to responses to the following question:

D. ''Would you say it has bothered you only a little, moderately, very much, not at all?'' (See pages 10 and 12 of the questionnaire.)

Table 4

Respondents who had indicated on question D that they were very much or moderately bothered were tabulated by ''frequency with which bothered'' on the basis of answers to question C (above) and an additional question:

E. ''How often has it bothered you? Is it almost every time, about half the time, less often?''

The definitions of ''frequency with which bothered'' in terms of responses to questions C and E are shown below:

How Often Noticed (Question C)	How Often Bothered (Question E)	
	Almost every time or about half the time	Less often or don't know
Every day	Often	Occasionally
At least once a week	Occasionally	Seldom
At least once a month	Seldom	Seldom
Less often or don't know	Seldom	Seldom

Table 5

Respondents who were very much or moderately bothered, as measured by responses to question D, were categorized by responses to the following three questions:

F. ''You said the odors have bothered you. Do you think it's better, worse, or the same this summer as last summer?'' (See page 13 of the questionnaire.)

If ''better'', question G was asked, if ''worse'', question H was asked.

G. ''Do you think it's because there is less odor or because you have become used to it?'' (See page 14 of the questionnaire.)

H. ''Do you think it's because there is more odor or because you are more sensitive to it?'' (See page 14 of the questionnaire.)

Table 6

Respondents who had indicated that they were bothered by pulp mill odors moderately or very much, were asked if they had any symptoms listed on page 13 of the questionnaire.

Table 7

Respondents were tabulated according to whether they mentioned the pulp mill odor ''spontaneously,'' gave a ''semi-probed'' response, or gave a ''probed'' response, defined as follows:

''Spontaneous mention of pulp mill odors'' was defined as mention of pulp mill odors in response to the following questions:

I. ''What are some of the things you don't like about living here?''

J. ''Have you ever felt like moving away from this residential area?'' If yes, ''when you have felt like moving away, what has the reason been?''

K. ''If you could find a similar apartment (house) which would not be more expensive in another residential area, would you like to move there?'' If yes, ''why would you like to do this?''

L. ''Is there anything here in the community that you think is harmful for you or your family?'' If yes, ''what is this?''

These questions occur early in the questionnaire before either pulp mill odors or odors from other industry have been mentioned by the interviewer. (See pages 4-6 of the questionnaire.)

‘‘*Semi-probed* mention of pulp mill odors’’ was defined as mention of pulp mill odors in response to the following question if the respondent had not already mentioned odor ‘‘spontaneously’’:

> M. ‘‘Have you noticed odors from industries here at home during the last three months?’’ If yes, ‘‘what industries?’’

This question occurred before the interviewer had specifically mentioned pulp mill odors. (See page 10 of the questionnaire.) Responses mentioning pulp mill odor were called ‘‘semi-probed’’ only if the respondent had not previously mentioned pulp mill odors.

‘‘*Probed* mention of pulp mill odors’’ was defined as a positive response to the following question, which was asked only if respondent had not already given a ‘‘probed’’ or ‘‘semi-probed’’ pulp mill response:

> N. ‘‘Some people here in Eureka have been complaining about odors from the pulp mills. Here in your house have you noticed the odors during the last three months?’’ (See page 12 of the questionnaire.)

‘‘*No* mention of pulp mill odors’’ was defined as a negative response to question N with no previous mention of pulp mill odors.

Table 8

Data shown on Table 8 were tabulated from positive responses with mention of pulp mill odor to the following questions:

> O. ‘‘Have you ever thought of requesting, or have you actually requested some authority or agency to take action concerning any of these problems, e.g., by writing or phoning an official,

signing a petition, or attending a meeting?'' If so, ''what problem was it?'' (See page 8 of the questionnaire.)

P. ''Have you ever felt like moving away from this residential area?'' If yes, ''when you have felt like moving away, what has the reason been?'' (See page 5 of the questionnaire.)

Table 9

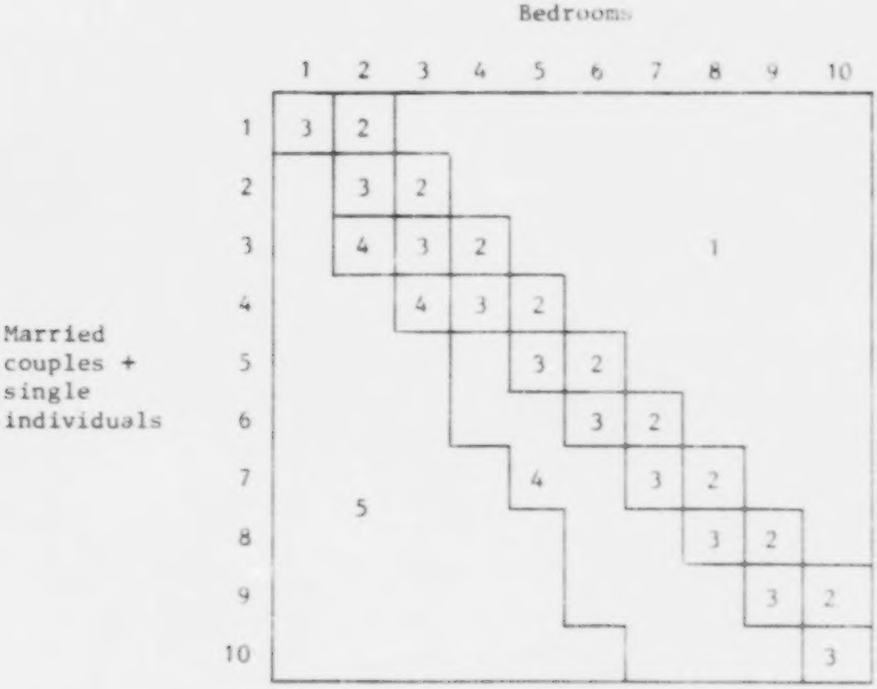
Background Variables

Attitude toward authorities was based on question 60, page 15 of the questionnaire.

Satisfaction with community was based on questions 5, 7, and 8, pages 4 and 5 of the questionnaire. Individuals who indicated that there were things other than pulp mill odor that they did not like about the residential area, were tested against all others. Those who didn't know whether to rate the community good, fair, or poor were included in the latter category.

Housing index was derived from the number of bedrooms in the household and the number of married couples, single adults and children. Households coded 1-2 as indicated below were tested against those coded 3-5.

Copies of the questionnaire are available from the authors.


Bedrooms
1 2 3 4 5 6 7 8 9 10
Married couples + single individuals
1 2 3 4 5 6 7 8 9 10
3 2
3 2
4 3 2
1
4 3 2
3 2
3 2
4
3 2
5
3 2
3 2
3

SECTION VI-B

HEALTH EFFECTS OF EXPOSURE TO COMMUNITY ODORS FROM PULP MILLS

EUREKA, 1971

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INTRODUCTION

Community odors associated with pulp mill operation have been the basis for spontaneous complaints to authorities.[1] Furthermore, studies designed especially to measure annoyance reactions have confirmed that residents of areas with greater exposure to the odors tend to notice the odor more frequently and to be bothered by it both more frequently and to a greater extent than residents with less exposure.[2-5] In addition, some studies have shown that people exposed to the odor attribute medical symptoms to it.[3,6]

The present report is based on a study of the health and annoyance reactions to pulp mill odor carried out in 1971 in Eureka, a coastal city in northern California with a population of about 30,000 located in an area in which the lumber industries play a major part in the economy. During part of the year, offshore winds carry odorous materials across Humboldt Bay from the pulp mills to residential and business areas of the city. The annoyance reactions have been described in detail elsewhere.[7] This report consists largely of a comparison of the frequency with which symptoms are reported in three areas representing high, moderate and low exposure to pulp mill odor.

METHODOLOGY AND MATERIALS

Sampling:

Three residential areas were chosen that were presumed to have different exposures to the pulp mill odors on the basis of location with respect to the mills and prevailing offshore winds. Area I is situated 1-2 miles southeast of the mills and is expected to be more frequently exposed to emissions from the pulp mills than the other two areas. Area II is located 2-3 miles east of the mills and is assumed to be exposed to the odor less frequently, while Area III, with the least exposure, is located approximately 4 miles east of the mills. The relative location of the pulp mills and the three areas is shown in Figure I.

With the exception of Area III these areas are the same used in a study of annoyance reactions conducted in Eureka in 1969.[6] The households sampled in 1969 were omitted from the sampling frames for Areas I and II. Area III for the current study was located adjacent to the corresponding area for the 1969 study since too few unsampled households remained in the old Area III.

About 50 households were chosen in each of the areas by systematic sampling with a random start. The original samples were augmented to replace unoccupied households by randomly selecting replacements between the sample households on each side of the vacant households. The sample sizes, the distribution of respondents by sex, and the proportion of interviews successfully completed are shown in Table 1, in which the numbers described as ''samples'' represent the total number of households approached, including both the vacant households and their replacements. It was determined randomly whether a man or woman (usually the head of household or spouse) was to be interviewed in each household, but if an adult of the designated sex was not living in the household, any adult living there was interviewed.

Exposure Data:

The exposure to odor in the three areas was estimated by dynamic olfactometry. The measurements are based on the ''odor dilution factor'' which is the ratio of ambient air (air to which the community is exposed) to odorless air at which the observer just detects odor. This is converted to the equivalent of parts per billion of a specific odorant by multiplying by the odor threshold of each observer, which is the ratio of a known dilution of a specific odorant to odorless air at which the observer just detects the odor.

The sensitivity of the method is a function of the observer's odor threshold and the lowest dilution of odorant to odorless air that can be measured on the olfactometer. Daily measurements were obtained during a single two week period in September. In addition, measurements taken during the 1969 study of annoyance reactions in the same areas were available. The latter consisted of daily measurements taken during three two-week periods in June, July, and August. In both years, two observers were exposed to the ambient air at several sites in each of the three areas at half hour intervals during the day. The odor thresholds of each observer was measured twice a day. The method of sampling the ambient air and the instrumentation and technique of using the olfactometer are described in detail elsewhere.[8-9]

Questionnaire and Interviewing

The questionnaire consisted of six major sections. The first section deals with such background data as age, occupation and and family structure; the second section with satisfaction with general conditions in the residential area in the community; and the third section with attitudes toward air pollution and noise problems in the residential area. The fourth section deals specifically with the annoyance effects of odors from pulp mills, and the fifth section consists of questions designed to measure attitudes toward pollution and noise problems in general. This report deals primarily with responses to the remaining section of the questionnaire, which deals with medical symptoms. It includes the basic questions from the British MRC questionnaire on cough, phlegm, shortness of breath, and chest illness. In addition, the respondents were asked whether they had been sick, been to a doctor or been a patient in a hospital within the last two weeks. A list of symptoms was then read to the respondent and he or she was asked whether each one was experienced frequently, occasionally or hardly ever. The respondent's perception of his own health was also evaluated in terms of excellent, good, fair or poor.

An interviewer training period of two to three days at the beginning of the field work included detailed explanation and discussion of each item in the questionnaire and the method of recording responses as well as practice in using the questionnaire by means of role playing. The practice interviews were recorded on tape and replayed for correction of errors and discussion of interviewing technique. This was followed by actual practice field interviews which were edited for omissions, inconsistencies, and errors in recording responses. Similar editing was done during the survey itself so that errors could be corrected while the field work was still in progress and interviewer performance could be evaluated and modified if necessary.

The interviewing was carried out in August following training of interviewers described in detail elsewhere.[6,7] The interview was introduced to the respondent as part of a survey on how people feel about the community in which they live as well as a health survey. In order to mask the principal aim of the study, no mention was made of odor from the pulp mills. This has been found in previous studies to be important in obtaining unbiased results.[10] In addition, the field work was completed as quickly as possible to reduce the possibility of the results being affected by discussion of the survey within the community.

In the following discussion, the three areas are designated Area I, Area II, and Area III, representing, respectively, the areas of high, moderate and low exposure to the odor.

RESULTS OF ANNOYANCE SURVEY

The results of the annoyance survey are presented in abbreviated form (Table 2) since their primary value in this report is to confirm that the area differences in exposure demonstrated in the 1969 survey of annoyance reaction to pulp mill odor were still valid in 1971. As in 1969, Area I still appears to have the greatest exposure to the odor as demonstrated by the frequency with which odor is noticed and the extent to which the respondent is bothered by it. Area III continues to experience the least exposure in most categories representing frequency with which odor is noticed, but the distinction between Areas II and III is not shown in the percents of individuals very much or moderately bothered by the odor when these are based only on the numbers of respondents who reported noticing the odor. These results could be a reflection of different exposure of the new Area III as defined in 1971 compared to Area III as originally defined in the 1969 survey, or it could represent atypical weather conditions which were observed to occur during the 1971 survey. A detailed comparison of the 1969 and 1971 annoyance survey results is presented in a separate report.[7]

RESULTS OF HEALTH SURVEY

The health questionnaire is divided into two parts. One part consists of questions on cough, phlegm, and shortness of breath from the British Medical Research Councel's (MRC) standardized questionnaire on respiratory symptoms.[11] The second consists of a list of symptoms which respondents were asked to characterize as being experienced ''frequently'', ''occasionally'', or ''hardly ever''. In addition, the respondents were asked whether they had been sick, visited to a doctor, or been in a hospital as a patient within the two weeks preceding the interview.

The results of the tests for area trends for the list of symptoms are summarized in Tables 3 through 5. There were obvious differences by sex in the proportions of respondents reporting the various symptoms frequently or occasionally (Table 4). For all areas combined, without exception a higher proportion of women than men reported experiencing each symptom although only nervousness and headache show statistically significant sex differences. Nervousness also showed significant sex differences within each area, headache did not. Since the proportion of women in each area varied inversely to the exposure of the area to pulp mill odors, this sex difference would be unlikely to explain the relationship observed between exposure and the frequency with which symptoms are reported. However, since the sex difference could compensate for real area differences in symptoms, which might then remain undetected, and since women do not report higher frequencies of symptoms in all areas, the following analysis is carried out separately by sex where the numbers of observations permit. The sex difference was not as consistent for the subgroup reporting symptoms frequently, possibly a reflection of the relatively small numerators (not shown in tables).

χ^2 tests to detect significant trends by area were carried out for all respondents (Table 3), for men and women separately (Table 4), and for those very much or moderately bothered by the odor as well as those only a little or not at all bothered (Table 5). These were done separately for those who reported symptoms frequently (not shown by sex or amount bothered on tables), and for a combined group representing those who reported symptoms frequently or occasionally. None were significant. However, since the estimation of exposure made from dynamic olfactometry, as well as some of the annoyance reactions, suggested that a more appropriate area gradient might be represented by using Area II to represent the least exposure, and Area III to represent moderate exposure, tests were also made for this trend. Significant area differences corresponding to differences in exposure to odor were found for the percent reporting constipation frequently or occasionally among women (Table 4) as well as among respondents of both sexes who were a little or not at all bothered by the pulp mill odor (Table 5).

Similar tests for area trends were made for responses to the MRC questions (Table 6). Only phlegm Grade 1 or greater gave significant results, and these occurred only among women and for both sequences of areas (Areas I, II, or III and Areas I, III, II). However, this could be related to the higher percent of smokers among women in Area I compared with Areas II and III. No significant trends for the MRC symptoms were found when tested separately within each "amount bothered by the odor" category (not shown on table). Although the interviewers were trained in the use of the MRC questions using standardized methods, slightly modified probing rules were used to simplify training. Therefore, the prevalence of symptoms shown in Tables 6 and 8 should not be compared directly with the results of other surveys using the standardized questions. In addition, although the MRC questions preceded the questions concerning the frequency of other symptoms, they followed the annoyance section of the questionnaire, and this could also have affected the results.

The significant trends reported above represent only those in the direction hypothesized from the exposure data, that is, those showing a positive relationship between symptoms and exposure to odor. Several symptoms showed significant area trends in a direction opposite to that which would support the hypotheses; these included sleeplessness, difficulty in urinating, sinus congestion, eye irritation, and runny nose.

For all areas combined, χ^2 tests were also done for the relationship between symptoms and amount bothered by the odor. Only the percent reporting headache frequently or occasionally showed a positive relationship to amount bothered; this occurred among women and in both sexes combined (Table 7). In spite of the lack of relationship found between this symptom and area of exposure, these results would support the hypothesis that headache may be related to exposure to the odor. None of the MRC questions showed a significant relationship to amount bothered by the odor (Table 8).

The distribution of the respondents by smoking within each area and sex is shown in Table 9. Because of the relatively small numbers of observations, it is not feasible to make area comparisons within each smoking category. However, the relatively large percent of smokers among women in Area I should be considered in interpreting the significantly higher proportion with Grade 1 or greater phlegm.

RESULTS OF EXPOSURE MEASUREMENTS

The most important results relevant to evaluation of the annoyance reactions are shown in Tables 10,11, and 12, which show, respectively, the percent of total observations which indicated detection of odor, diurnal odor concentration at the 95th percentile, and the maximum odor concentration detected. The percent of measurable odor detections (Table 10) indicates that odor was detected by dynamic olfactometry most frequently in Area I and least frequently in Area II. These trends are confirmed by the 95th percentiles for each hour for all days combined (Table 11), and by the means of the maximum values for each hour (Table 12).

SUMMARY AND DISCUSSION

The results of the 1971 survey of annoyance reactions showed that, as in the 1969 survey, Area I represents the area of greatest exposure to odor from the pulp mills. This was confirmed by the exposure measurements made by dynamic olfactometry. The area gradient between Areas II and III was not as clear, although it was still demonstrable in terms of the frequency with which odor was noticed. In view of the ambiguous results of annoyance as measured by amount bothered by odor and by the observations made by dynamic olfactometry, the frequency with which symptoms were reported was tested for two possible area trends:

Areas I, II, III and Areas I, III, II. Constipation showed a significant area trend using the former sequence of areas, while Phlegm Grade I or greater showed a significant trend for both sequences. For all areas combined, headache showed a positive relationship to the amount by which the respondent was bothered by the odor. No significant trends or relationship to amount bothered were found for visits to a doctor or a hospital or for illness during the two weeks preceding the interview, or for the respondents estimate of general health.

The evidence supporting a possible causative relationship between health and exposure to pulp mill odor is based on small numbers of observations. The relatively small numbers of observations prohibited adequately accessing the possible role of smoking.

Table 1

DESCRIPTION OF POPULATION SAMPLES BY AREA AND SEX

EUREKA, 1971

	AREA I			AREA II			AREA III		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Sample Size	51	24	27	52	24	28	54	22	32
Respondents	45	20	25	47	20	27	48	20	28
Non Respondents	5	3	2	3	2	1	2		2
Refusals	3	1	2	2	1	1	1		1
Unable to Locate	2	2		1	1		1		1
Dwelling Unit Unoccupied	1	1		2	2		4	2	2

Table 2

FREQUENCY WITH WHICH PULP MILL ODOR WAS NOTICED AND EXTENT TO WHICH BOTHERED

EUREKA, 1971

	TOTAL				MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	140	45	47	48	60	20	20	20	80	25	27	28
How Often Noticed, Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Every Day	7.9	13.3	6.4	4.2	6.7	15.0	5.0		8.8	12.0	7.4	7.1
At Least Once a Week	30.7	48.9	31.9	12.5	23.3	40.0	20.0	10.0	36.2	56.0	40.7	14.3
At Least Once a Month	22.9	26.7	29.8	12.5	23.3	30.0	30.0	10.0	22.5	24.0	29.6	14.3
Less Often or Don't Know	12.1	6.7	10.6	18.8	13.3	5.0	10.0	25.0	11.2	8.0	11.1	14.3
Not Noticed at All	26.4	4.4	21.3	52.1	33.3	10.0	35.0	55.0	21.2		11.1	50.0
How Much Bothered, Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Very Much or Moderately	40.7	62.2	36.2	25.0	33.3	55.0	25.0	20.0	46.2	68.0	44.4	28.6
Little or Not at All, or Odor Not Noticed	53.6	37.8	59.6	62.5	58.3	45.0	65.0	65.0	50.0	32.0	55.6	60.7
Unknown	5.7		4.3	12.5	8.3		10.0	15.0	3.8			10.7
Number Who Noticed Odor	111	43	39	29	45	18	15	12	66	25	24	17
How Much Bothered, Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Very Much or Moderately	51.4	65.1	43.6	41.4	44.4	61.1	33.3	33.3	56.1	68.0	50.0	47.1
Little or Not at All	41.4	34.9	51.3	37.9	44.4	38.9	53.3	41.7	39.4	32.0	50.0	35.3
Unknown	7.2		5.1	20.7	11.1		13.3	25.0	4.5			17.6

Table 3

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY AND FREQUENTLY OR OCCASIONALLY

EUREKA, 1971

	FREQUENTLY OR OCCASIONALLY				FREQUENTLY			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	140	45	47	48	140	45	47	48
Nervousness	55.7	55.6	53.2	58.3	20.0	26.7	12.8	20.8
Headache	37.9	40.0	31.9	41.7	10.0	13.3	8.5	8.3
Sleeplessness	32.1	31.1	29.8	35.4	10.7	4.4	12.8	14.6
Dizziness, Nausea, or Vomiting	7.9	8.9	8.5	6.2	0.0	0.0	0.0	0.0
Constipation	15.7	22.2	8.5	16.7	3.6	2.2	2.1	6.2
Pain in Joints	37.9	44.4	36.2	33.3	14.3	17.8	17.0	8.3
Difficulty in Urinating	2.9	2.2	6.4	0.0	0.7	0.0	2.1	0.0
Sinus Congestion	42.1	37.8	31.9	56.2	19.3	13.3	21.3	22.9
Eye Irritation	21.4	13.3	21.3	29.2	7.9	0.0	12.8	10.4
Burning or Irritation of the Nose	12.1	8.9	12.8	14.6	3.6	0.0	4.3	6.2
Runny Nose	28.6	24.4	27.7	33.3	8.6	2.2	6.4	16.7
Chest Pains	5.7	8.9	4.3	4.2	1.4	0.0	2.1	2.1

Table 4

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY OR OCCASIONALLY BY SEX AND AREA

EUREKA, 1971

	MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	60	20	20	20	80	25	27	28
Nervousness	31.7	35.0	30.0	30.0	73.8	72.0	70.4	78.6
Headache	26.7	25.0	25.0	30.0	46.2	52.0	37.0	50.0
Sleeplessness	30.0	20.0	30.0	40.0	33.8	40.0	29.6	32.1
Dizziness, Nausea, or Vomiting	5.0	5.0	10.0	0.0	10.0	12.0	7.4	10.7
*Constipation	15.0	15.0	10.0	20.0	16.2	28.0	7.4	14.3
Pain in Joints	36.7	35.0	35.0	40.0	38.8	52.0	37.0	28.6
Difficulty in Urinating	1.7	0.0	5.0	0.0	3.8	4.0	7.4	0.0
Sinus Congestion	38.3	30.0	25.0	60.0	45.0	44.0	37.0	53.6
Eye Irritation	18.3	15.0	15.0	25.0	23.8	12.0	25.9	32.1
Burning or Irritation of the Nose	11.7	10.0	15.0	10.0	12.5	8.0	11.1	17.9
Runny Nose	25.0	20.0	30.0	25.0	31.2	28.0	25.9	39.3
Chest Pains	3.3	10.0	0.0	0.0	7.5	8.0	7.4	7.1

* Trend significant at the 5% level among women for the area sequence I, III, II (χ^2=4.01 with 1 degree of freedom).

Table 5

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY OR OCCASSIONALLY BY AREA AND AMOUNT BOTHERED BY PULP MILL ODOR

EUREKA, 1971

	VERY MUCH OR MODERATELY BOTHERED BY PULP MILL ODOR				LITTLE OR NOT AT ALL BOTHERED BY PULP MILL ODOR			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	57	28	17	12	75	17	28	30
Nervousness	59.6	50.0	64.7	75.0	53.3	64.7	46.4	53.3
Headache	50.9	50.0	52.9	50.0	28.0	23.5	21.4	36.7
Sleeplessness	33.3	32.1	35.3	33.3	33.3	29.4	28.6	40.0
Dizziness, Nausea, or Vomiting	12.3	10.7	11.8	16.7	5.3	5.9	7.1	3.3
*Constipation	21.1	21.4	17.6	25.0	13.3	23.5	3.6	16.7
Pain in Joints	42.1	46.4	41.2	33.3	36.0	41.2	35.7	33.3
Difficulty in Urinating	3.5	0.0	11.8	0.0	2.7	5.9	3.6	0.0
Sinus Congestion	42.1	42.9	35.3	50.0	42.7	29.4	28.6	63.3
Eye Irritation	26.3	14.3	35.3	41.7	17.3	11.8	14.3	23.3
Burning or Irritation of the Nose	17.5	14.3	17.6	25.0	8.0	0.0	10.7	10.0
Runny Nose	35.1	35.7	35.3	33.3	24.0	5.9	25.0	33.3
Chest Pain	7.0	10.7	0.0	8.3	5.3	5.9	7.1	3.3

Trends significant at the 5% level among those a little or not at all bothered for the area sequence I, III, II (χ^2=3.97 with 1 degree of freedom

Table 6

PERCENT REPORTING COUGH, PHLEGM, SHORTNESS OF BREATH, AND RECENT ILLNESS BY SEX AND AREA

EUREKA, 1971

	TOTAL			MALE			FEMALE		
	Area I	Area II	Area III	Area I	Area II	Area III	Area I	Area II	Area III
Number of Observations	45	47	48	20	20	20	25	27	28
Cough Grade 1 or 2	24.4	14.9	27.1	25.0	10.0	35.0	24.0	18.5	21.4
Cough Grade 2	11.1	8.5	10.4	10.0	5.0	10.0	12.0	11.1	10.7
*Phlegm Grade 1 or 2	24.4	10.6	10.4	15.0	10.0	15.0	32.0	11.1	7.1
Phlegm Grade 2	11.1	6.4	6.2	10.0	10.0	5.0	12.0	3.7	7.1
Persistent Cough and Phlegm	13.3	6.4	8.3	15.0	5.0	15.0	12.0	7.4	3.6
Shortness of Breath									
Grade 2 or Greater	40.0	31.9	33.3	40.0	30.0	25.0	40.0	33.3	39.3
Grade 3 or Greater	2.2	8.5	6.2	0.0	5.0	0.0	4.0	11.1	10.7
Sick Within Last 2 Weeks	8.9	10.6	8.3	5.0	10.0	0.0	12.0	11.1	14.3
Saw Doctor Within Last 2 Weeks	15.6	21.3	14.6	20.0	20.0	15.0	12.0	22.2	14.3
Patient in Hospital Within Last 2 Weeks	2.2	2.1	2.1	5.0	0.0	0.0	0.0	3.7	3.6
General Estimate of Health									
Excellent or Good	77.8	87.2	83.3	75.0	90.0	85.0	80.0	85.2	82.1
Fair or Poor	22.2	12.8	16.7	25.0	10.0	15.0	20.0	14.8	17.9

* Trend significant at the 5% level for females for area sequences I, II, III and I, III, II (χ^2=5.85 and 4.01 with 1 degree of freedom).

Table 7

PERCENT REPORTING SYMPTOMS FREQUENTLY OR OCCASSIONALLY BY SEX AND AMOUNT BOTHERED BY PULP MILL ODOR

EUREKA, 1971

	BOTH SEXES			MALE			FEMALE		
	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered
Number of Respondents	140[a]	57	75	60[b]	20	35	80[c]	37	40
Nervousness	55.7	59.6	53.3	28.3	30.0	31.4	71.2	75.7	72.5
*Headache	37.9	50.9	28.0	25.0	35.0	22.9	43.8	59.5	32.5
Sleeplessness	32.1	33.3	33.3	28.3	30.0	31.4	33.8	35.1	35.0
Dizziness, Nausea, or Vomiting	7.9	12.3	5.3	5.0	5.0	5.7	10.0	16.2	5.0
Constipation	15.7	21.1	13.3	15.0	15.0	17.1	16.2	24.3	10.0
Pain in Joints	37.9	42.1	36.0	35.0	45.0	34.3	37.5	40.5	37.5
Difficulty in Urinating	2.9	3.5	2.7	1.7	0.0	2.9	3.8	5.4	2.5
Sinus Congestion	42.1	42.1	42.7	35.0	35.0	40.0	43.8	45.9	45.0
Eye Irritation	21.4	26.3	17.3	16.7	25.0	14.3	22.5	27.0	20.0
Burning or Irritation of the Nose	12.1	17.5	8.0	10.0	15.0	8.6	12.5	18.9	7.5
Runny Nose	28.6	35.1	24.0	23.3	15.0	25.7	30.0	40.5	22.5
Chest Pains	5.7	7.0	5.3	3.3	10.0	0.0	7.5	5.4	10.0

[a] Includes 8 amount bothered unknown.
[b] Includes 5 amount bothered unknown.
[c] Includes 3 amount bothered unknown.

* χ^2 tests for percent reporting symptoms by amount bothered statistically significant at 5% level (χ^2=6.23 for both sexes combined; χ^2=5.63 for females).

Table 8

PERCENT REPORTING COUGH, PHLEGM, SHORTNESS OF BREATH, AND RECENT ILLNESS BY SEX AND AREA

EUREKA 1971

	BOTH SEXES			MALE			FEMALE		
	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered
Number of Observations	140[a]	57	75	60[b]	20	35	80[c]	37[a,b]	40
Cough Grade 1 or 2	22.1	19.3	24.0	23.3	20.0	22.9	21.2	18.9	25.0
Cough Grade 2	10.0	7.0	10.7	8.3	5.0	5.7	11.2	8.1	15.0
Phlegm Grade 1 or 2	15.0	14.0	14.7	13.3	15.0	8.6	16.2	13.5	20.0
Phlegm Grade 2	7.9	8.8	6.7	8.3	15.0	2.9	7.5	5.4	10.0
Persistent Cough and Phlegm	9.3	7.0	9.3	11.7	10.0	8.6	7.5	5.4	10.0
Shortness of Breath									
Grade 2 or Greater	35.0	40.4	33.3	31.7	45.0	25.7	37.5	37.8	40.0
Grade 3 or Greater	5.7	5.3	6.7	1.7	5.0	0.0	8.8	5.4	12.5
Sick Within Last 2 Weeks	9.3	12.3	8.0	5.0	10.0	2.9	12.0	13.5	12.5
Saw Doctor Within Last 2 Weeks	17.1	19.3	16.0	18.3	30.0	14.3	16.2	13.5	17.5
Patient in Hospital Within Last 2 Weeks	2.1	1.8	2.7	1.7	0.0	2.9	2.5	2.7	2.5
General Estimate of Health									
Excellent or Good	82.9	77.2	88.0	83.3	80.0	88.6	82.5	75.7	87.5
Fair or Poor	17.1	22.8	12.0	16.7	20.0	11.4	17.5	24.3	12.5

[a] Includes 8 amount bothered unknown.
[b] Includes 5 amount bothered unknown.
[c] Includes 3 amount bothered unknown.

Table 9

DISTRIBUTION OF RESPONDENTS BY SMOKING CATEGORY WITHIN EACH AREA AND SEX

SMOKING HISTORY	TOTAL			MALE			FEMALE		
	Area I	Area II	Area III	Area I	Area II	Area III	Area I	Area II	Area III
	45	47	48	20	20	20	25	27	28
Never Smoked	17.8	40.4	33.3	10.0	20.0	25.0	24.0	55.6	39.3
Ex-Smokers	13.3	19.1	22.9	20.0	30.0	20.0	8.0	11.1	25.0
Present Cigarette Smokers	57.8	31.9	43.8	45.0	35.0	55.0	68.0	29.6	35.7
Pipe and Cigar or Mixed Smokers	11.1	8.5	0.0	25.0	15.0	0.0	0.0	3.7	0.0

Table 10

PERCENT MEASURABLE ODOR DETECTIONS (ODOR FREQUENCY)

EUREKA, 1971

TIME OF DAY	AREA I	AREA II	AREA III
Total 0800-1630			
Number of Observations	190	285	376
Percent With Odor	19.5	6.0	13.3
0800-1130			
Number of Observations	85	123	172
Percent With Odor	4.7	3.3	7.0
1200-1630			
Number of Observations	105	162	204
Percent With Odor	31.4	8.0	18.6

Table 11

DIURNAL MALODOR CONCENTRATION AT 95th PERCENTILE BY AREA AND TIME

(as ppb CH_3SH)

EUREKA, 1971

TIME OF DAY	AREA I	AREA II	AREA III
0800	4.1	N.D.	4.2
0830	N.D.	N.D.	3.4
0900	N.D.	N.D.	N.D.
0930	N.D.	N.D.	N.D.
1000	N.D.	N.D.	N.D.
1030	N.D.	N.D.	N.D.
1100	N.D.	N.D.	13.5
1130	3.9	15.3	N.D.
1200	9.0	N.D.	N.D.
1230	2.0	N.D.	8.6
1300	4.8	6.6	N.D.
1330	9.9	N.D.	0.4
1400	13.6	3.8	N.D.
1430	2.7	N.D.	7.3
1500	21.0	3.4	15.0
1530	N.D.	8.7	8.8
1600	9.7	1.1	10.4
1630	12.8	N.D.	14.5
Percent Detectable	61.1	33.3	55.6
Mean of Measurable Detections	8.5	6.5	8.6

Table 12

MAXIMUM MALODOR CONCENTRATION DETECTED*
BY AREA AND TIME
(as ppb CH_3SH)

EUREKA, 1971

SAMPLING INTERVAL BEGUN AT	AREA I	AREA II	AREA III
0800	5.1	N.D.	4.2
0830	N.D.	N.D.	5.1
0900	N.D.	N.D.	N.D.
0930	N.D.	N.D.	N.D.
1000	N.D.	N.D.	N.D.
1030	N.D.	N.D.	N.D.
1100	N.D.	N.D.	16.9
1130	6.5	16.9	N.D.
1200	17.9	N.D.	N.D.
1230	5.0	N.D.	9.8
1300	7.9	0.7	5.1
1330	11.3	N.D.	2.2
1400	16.5	6.3	N.D.
1430	2.8	N.D.	47.8
1500	14.8	3.4	20.6
1530	N.D.	9.1	9.9
1600	11.5	11.1	11.6
1630	14.1	3.8	15.4
Percent Detectable	61.1	38.9	61.1
Mean of Measurable Detections	10.3	7.3	13.5

* In each case the concentration ranged from none detected to the maximum shown.

N.D. None detected which means less than 2 x minimum O.T. of the observer essentially 0.

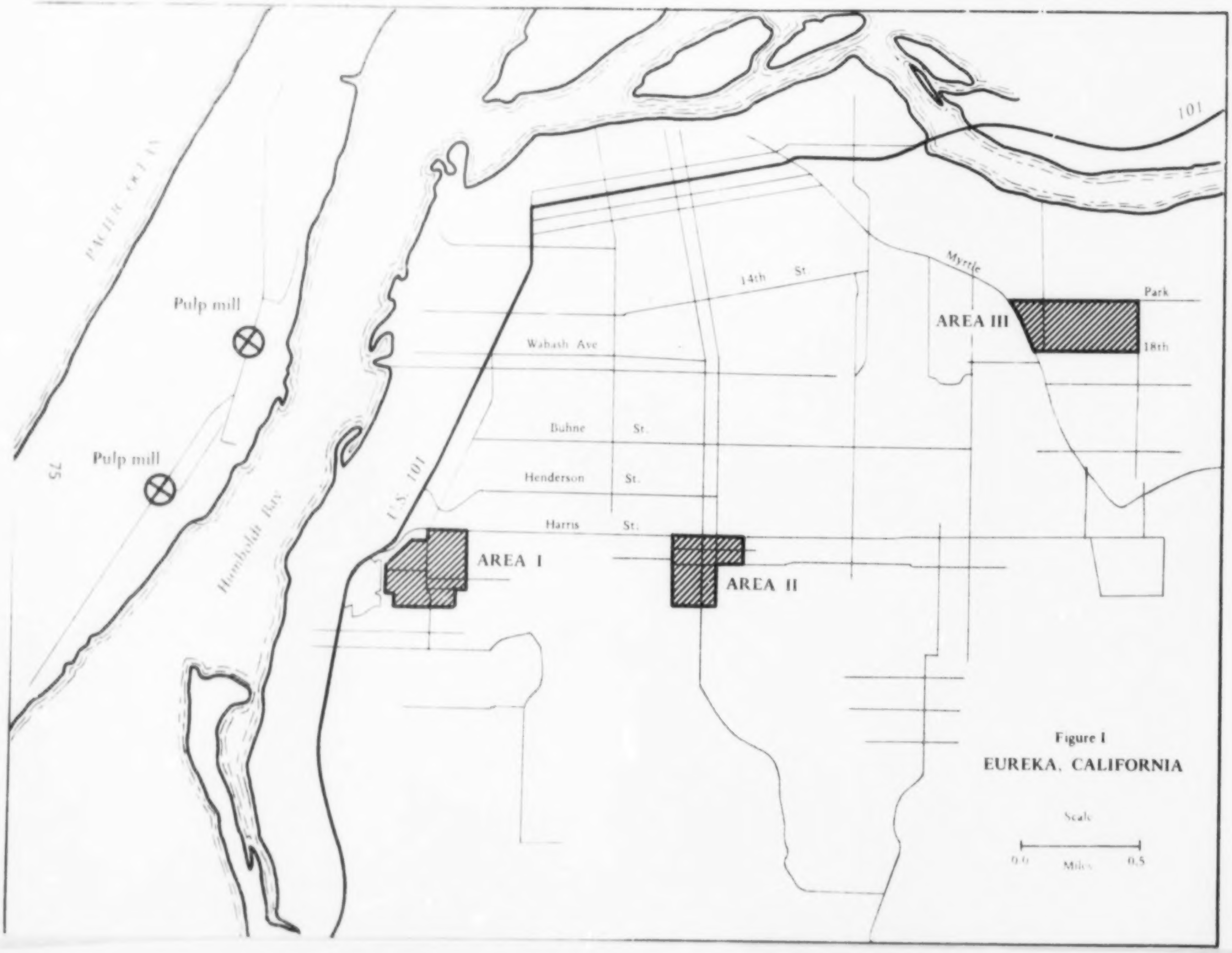
PACIFIC OCEAN
Pulp mill
Pulp mill
Humboldt Bay
U.S. 101
101
Myrtle
14th St.
Wabash Ave
Buhne St.
Henderson St.
Harris St.
Park
18th
AREA I
AREA II
AREA III
Scale
0.0
Miles
0.5

Figure I
EUREKA, CALIFORNIA

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HEALTH EFFECTS OF EXPOSURE TO COMMUNITY ODORS FROM PULP MILLS

Eureka, 1971

APPENDIX

Definitions of Variables

Table 2

Positive responses to two questions were used to measure the frequency with which pulp mill odor was noticed by the respondent:

A. "Have you noticed odors from industries here at home during the last three months? What industries?" (Pulp mills were not specifically mentioned to the respondent. See page 10 of the questionnaire.)

B. "Some people here in Eureka have been complaining about odors from the pulp mills. Here in your house have you noticed the odors during the last three months?" (This question was asked only of respondents who had not already mentioned pulp mill to the question concerning odors from industry. See page 12 of the questionnaire.)

For each question, respondents who gave a positive response were asked:

C. "How often? Is it every day, at least once a week, at least once a month, or less often?" The "not noticed at all" category included individuals who did not know whether they had noticed the pulp mill odor. (See pages 10 and 12 of the questionnaire.)

Individuals who had given positive answers to either questions A or B (above) were classified according to the extent bothered by pulp mill odor according to responses to the following question:

D. "Would you say it has bothered you only a little, moderately, very much, not at all?" (See pages 10 and 12 of the questionnaire.)

Tables 3-5, 7

The frequency with which symptoms were reported were tabulated from responses to the following:

> "I am going to read you a list of symptoms and I should like you to tell me whether you have each one frequently, occasionally or hardly ever."

Tables 6, 8

The tables on cough, phlegm, and shortness of breath were tabulated from responses to the following section of the questionnaire:

PREAMBLE: "I am going to ask you some questions, mainly about your chest. I should like you to answer 'YES' or 'NO' whenever possible."

COUGH

1. "Do you usually cough first thing in the morning (on getting up)?"
Count a cough with first smoke or on first going out of doors.
Exclude clearing throat or a single cough.

3. "Do you usually cough during the day - or at night?"
Ignore an occasional cough.

If 'No' to both questions 1 and 3, go to question 6.

If 'Yes' to either question 1 or 3:

5. "Do you cough like this on most days (or nights) for as much as three months each year?"

PHLEGM

6. "Do you usually bring up any phlegm from your chest first thing in the morning (on getting up)?"
Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.

8. "Do you usually bring up any phlegm from your chest during the day - or at night?"

Accept twice or more.

If 'Yes' to either question 6 or 8:

10. "Do you bring up phlegm like this on most days (or nights) for as much as three months each year?"

BREATHLESSNESS

14a. "Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?"

If 'Yes' to question 14a:

14b. "Do you get short of breath walking with other people of your own age on level ground?"

If 'Yes' to question 14b:

14c. "Do you have to stop for breath when walking at your own pace on level ground?"

Cough, phlegm, and shortness of breath were graded as follows:

Cough Grade 0: 'No' to both questions 1 and 3 or 'no' to question 5.

Grade 1: 'Yes' to either questions 1 or 3 and 'yes' to question 5.

Grade 2: 'Yes' to both questions 1 and 3 and 'yes' to question 5.

Phlegm Grade 0: 'No' to both questions 6 or 8 or 'no' to question 10.

Grade 1: 'Yes' to *either* questions 6 or 8 and 'yes' to question 10.

Grade 2: 'Yes' to *both* questions 6 and 8 and 'yes' to question 10.

Shortness of Breath

Grade 1: 'No' to question 14a.

Grade 2: 'Yes' to question 14a and 'no' to question 14b.

Grade 3: 'Yes' to question 14b and 'no' to question 14c.

Grade 4: 'Yes' to question 14c.

TRENDS IN COMMUNITY ANNOYANCE REACTIONS TO ODORS FROM PULP MILLS

EUREKA, CALIFORNIA

1969, 1971

Introduction

Perhaps no more pervasive nor offensive odor exists in community air pollution than that associated with pulp mill operation. Previous studies have shown that exposure to the odor may result in spontaneous complaints and in frequent expressions of annoyance in response to interviews conducted as part of a community survey.[1-5] In addition, some evidence has been accumulated suggesting the existence of medical symptoms which are attributed by the sufferer to pulp mill odor.[3,6]

In 1969 a systematic survey of annoyance reactions to pulp mill odor was undertaken in Eureka, California. The primary objective of the study was to determine whether a relationship between annoyance reactions and exposure measurements could be demonstrated by the comparison of residential areas with different presumptive exposure to the odor (based on distance from the mill and meteorological conditions). It was shown that both the frequency with which odor was noticed and the frequency and intensity with which respondents to an interview expressed annoyance corresponded to the presumptive exposure gradient across three residential areas. This gradient was confirmed by exposure measurements made by a survey of the areas using dynamic olfactometry. These results and the methods used have been described in detail elsewhere.[6-8]

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In 1971 a repeat survey of annoyance reactions was supplemented by an expanded health survey with two objectives. First, to estimate change in annoyance reactions using the results of the 1969 survey as a basis for comparison and, second, to determine whether significant differences in responses to the health questionnaire were related to the degree of exposure to pulp mill odor. Because of the differences in the medical sections of the 1969 and 1971 surveys it was not possible to make direct comparisons between the two studies in this respect. The results of the medical study, therefore, will be reported elsewhere, and this report is limited to a comparison of annoyance reactions.

Methodology and Materials

The same general methods of sampling and of carrying out the field work were used in both 1969 and 1971. Two of the three residential areas had the same boundaries in both studies, but the samples for the 1971 survey were chosen so as to exclude households that were included in the 1969 survey (systematic sample using a random start in each area). The third area was so small that it would not have been possible to choose a sample of adequate size without including some of the households sampled in 1969. Therefore, a nearby area was used which was judged to have about the same exposure and the same general socioeconomic level. The composition of the samples and their sex distribution is shown in Table 1. The original samples were augmented to replace unoccupied houses; the numbers described as "sample" include these additional households and represent the total numbers of houses approached. The methods of replacement were, however, somewhat different in each year. In 1969 larger samples than needed were initially selected in each area and a portion of each was randomly selected to be held for use in replacing vacant houses. In 1971, replacement of each vacant house was made after the selection of the initial sample by randomly selecting a replacement between the sample households on either side. In both surveys it was randomly determined for each household whether a man or a woman (usually the head of household or spouse) was to be interviewed, but if an adult of the designated sex was not living in the household, any available adult was interviewed. Because of the sample design and the population structure of the area surveyed, more women than men were represented among the respondents.

Exposure Data

The exposure to odor in the three areas was estimated by dynamic olfactometry. The measurements are based on the "odor dilution factor" which is the ratio of ambient air (air to which the community is exposed) to odorless air at which the observer just detects malodor. This is converted to the equivalent of parts per billion of a specific odorant by multiplying by the odor threshold of each observer, which is the ratio of a known dilution of a specific odorant to odorless air at which the observer just detects the malodor.

The sensitivity of the method is a function of the observer's odor threshold and the lowest dilution of odorant to odorless air that can be measured on the olfactometer. In 1969, daily measurements were made during three two-week periods in June, July, and August. In 1971, daily measurements were made during a single two-week period in September. Two observers were exposed to the ambient air at several sites in each of the three areas at half-hourly intervals during the day. The odor threshold of each observer was measured twice a day. The sampling sites, the method of sampling the ambient air and the instrumentation and technique of using the olfactometer are described in detail elsewhere.[7,8]

Questionnaire and Interviewing

The questionnaires for both the 1969 and the 1971 surveys consist of five major sections exclusive of the health section (Appendix). The first section deals with such background data as age, occupation and family structure; the second section with satisfaction with general conditions in the residential area in the community; and the third section with attitudes toward air pollution and noise problems in the residential area. The questions of greatest interest in the study occur in the fourth section, which deals specifically with the effects of odors from pulp mills. The fifth section of the questionnaire consists of questions designed to measure attitudes toward pollution and noise problems in general. In 1971, the questionnaire included, in addition, an expanded health section with questions to be asked of all respondents.

In both 1969 and 1971 the interviewing was carried out in August, a similar method of training the interviewers was used in both studies, and in both studies the interviewing was completed as quickly as possible to reduce the possibility of the results being affected by discussion of the survey within the community. The interview was introduced to the respondents as part of a survey on how people feel about the community in which they live. In order to mask the principal aim of the study no mention was made of health or of odor from the pulp mills. This has been found in previous studies to be important in obtaining unbiased results.[9]

In the following discussion, the three areas are designated Area I, Area II and Area III representing, respectively, the areas of high, moderate and low exposure.

Results of Annoyance Survey

1. Perception of the Exposure Situation

The frequency with which the respondents reported noticing the pulp mill odor was used as a measure of their perception of the odor situation, as shown in Table 2.

To simplify the discussion of area comparisons of responses by frequency category, the following designations will be used:

A. Every day
B. At least once a week (but less often than every day)
C. At least once a month (but less often than once a week)
D. Less often than once a month
E. Not at all

Between 1969 and 1971 the overall proportion of individuals in Cateory A dropped by about one-third (Figure I), with a smaller drop occurring in Category B. The decreases in these proportions were offset principally by an increase in the proportion in Category C. Less change occurred in the proportions in Categories D and E. In other words, almost as large a proportion of individuals noticed the odor in 1971 as in 1969, but on the average they noticed it less frequently. These trends occurred within both Areas I and II, but Area III (the area with the least presumptive exposure to the odor) showed a somewhat different pattern. Increases occurred in the proportions in Categories A, B and E, offset by a large decrease in Category C and a small decrease in Category D. Thus in Area III there was some overall increase in the proportion noticing the odor, and those who noticed it tended to notice it more frequently. This may be due either to changes in exposure to odor or to changes in sensitivity. The same between-area gradients are maintained in both years as shown by cumulative frequency curves in Figure II.

II. Annoyance Reactions

A. Extent to Which Bothered by the Odor

In all three areas there was an overall marked decrease between 1969 and 1971 in the proportion of individuals "not at all bothered" by the odor based only on those who reported noticing the odor (Table 3). In Areas I and II decreased also occurred in the proportion "very much bothered", offset principally by increased in the proportions "moderately bothered" or "a little bothered". In Area III (the least exposed area) the very sharp drop in the proportion "not bothered at all" is offset by increases in all the other three categories but especially in the "very much bothered" category (almost double). These trends are summarized in Figure III. As can be seen in both Figures III and IV, the area differences in degree of annoyance are less in 1971 than in 1969. It is also demonstrated in Figure IV that the differences between areas in 1971 did not follow the area differences in presumptive odor exposure. To summarize, a larger proportion of people were bothered in 1971, but except in Area III, they were bothered to a smaller extent than in 1969.

B. Frequency With Which Bothered by the Odor

Based only on individuals who reported being very much or moderately bothered by the odor, the proportions of the respondents bothered "often" and "occasionally" decreased between 1969 and 1971 and the proportions "seldom bothered" more than doubled (Table 4, Figure V); these trends, however, occurred only in Areas I and II, the reverse being noted in Area III. As shown in Figure VI, between-area differences based on cumulative proportions occurred about as expected.

III. Implications of the Annoyance Reactions

In both surveys respondents were given an opportunity to mention the pulp mill odor in response to open-ended questions concerning community problems (spontaneous mention of odor), in response to open-ended questions about odor from industries (semi-probed mention of odor), and in response to specific questions about pulp mill odor (probed mention of odor). The resulting variable is interpreted as a measure of the saliency of the problem as perceived by the respondent.

As shown in Table 5, the proportions of respondents in 1969 who mentioned odor spontaneously in Areas I, II and III were, respectively, 52%, 20% and 4%. The corresponding proportions in 1971 were 44%, 36% and 19%. In both years the respondents who were very much or moderately bothered by the pulp mill odor tended to mention the odor in response to the open-ended questions on disadvantages of living in the community, reasons for considering moving, or harmful influences in the community. In contrast, those who reported being only a little or not at all bothered by the odor were more apt not to mention it until asked specifically about odors from industries. Only seven individuals in 1969 and two in 1971 who had not previously mentioned the pulp mill odor gave positive responses to a direct question about it.

The importance of pulp mill odors as a community problem was also evaluated by tabulating the responses to a question asking whether the respondent had ever thought of requesting, or had actually requested, some authority or agency to take action concerning the odors. The responses are shown in Table 6. The "thought of taking action" category also includes individuals who had given the pulp mill odors as a reason why they had felt like moving away from the community in response to an earlier question. In both years about the same proportion (46.2% in 1969 compared to 40.4% in 1971) of those very much or moderately bothered had taken some action concerning the odor, such as writing or phoning an official, signing a petition, or attending a meeting. However, a considerable increase (from 0.9% to 25.3%) occurred in the proportion of those only a little or not at all bothered who had taken action. Furthermore, in 1969 the expected area differences (a greater tendency toward action among those living in areas with greater exposure to the odor) occurred in the "very much or moderately bothered" category, while in 1971 the expected area differences occurred in the "little or not at all bothered" category, but not among those "very much or moderately bothered".

IV. Relevance of the Background Variables to Annoyance Reactions

Both surveys included questions to provide information on variables which might cause apparent area differences in annoyance reactions. Two-by-two tables were constructed comparing responses on each of these "background" variables with the annoyance variable, which was based on whether or not the respondent was very much or moderately bothered by the pulp mill odor. The construction and results of the χ^2 tests for the 1969 data are shown in detail in a previous paper.[3] The results for both years are summarized in Table 7. Two differences between the two years should be noted; in 1971, a χ^2 significant at the 5% level was obtained for the relationship between the annoyance variable and whether or not the respondent or spouse held a job associated with the mills. This relationship had not been found in 1969, but this might have been a result of the small number of individuals in the sample with jobs at the mills (8 out of 158 in 1969 compared to 19 out of 132 in 1971). The other difference was a nonsignificant χ^2 obtained in 1971 for the housing index, which had shown a significant relationship to the annoyance variable in 1969.

In Table 7 the underlined category for each variable is that category with the larger proportion of respondents who were "very much or moderately bothered" in both years. With respect to occupation, "estimation of noise problem in Eureka" and "concern about other community problems", the relationships to annoyance were opposite in 1971 to those occurring in 1969, but neither of these relationships was significant.

Of the variables showing a significant relationship to annoyance, all except age, household structure, housing index, and job associated with the mills could have been an effect of, as well as a cause of, annoyance. In any case, the area differences in the proportion of individuals annoyed when examined within strata of each significant background variable conformed to the overall area differences, and it is, therefore, unlikely that the overall area differences merely reflected differences in the background variables (Tables 8 and 9).

Results of Exposure Measurements

A summary of the exposure measurements made by dynamic olfactometry is presented in Tables 10, 11 and 12 which show, respectively, the percent of odor observations which indicate a measurable detection of odor, the diurnal malodor concentration at the 95th percentile and the maximum malodor concentration detected. In 1969 comparison of results for the three areas showed that Area I had the greatest exposure to odor, Area II had an intermediate exposure, and Area III had the least exposure, regardless of which of these three indices of exposure is used. This agrees with the presumptive exposure of the areas to pulp mill odor, as well as with the annoyance reactions of the respondents in each area. However, in 1971, this area gradient did not occur in the olfactometry measurements, nor did the annoyance reactions show as consistent a gradient as had been demonstrated in 1969. The percent of dynamic olfactometry measurements in which odor was detected showed the expected drop from Area I and Area II, but Area III showed a percent of detections about midway between the percents for Areas I and II in the afternoon hours and a higher percent of detections than either Areas I or II in the morning (Table 10). Area III showed about the same percent of detections as Area I at both the 95th percentile and the maximum (Tables 11 and 12). Furthermore, the arithmetic means of the detectible odor concentration for Area III exceeded those of Area I, both at the 95th percentile and at the maximum (Table 13). These measurements are summarized in Table 14, which also shows that Area III had a larger number of observations (by half-hourly intervals) which showed an increase over the two-year period than Areas I and II regardless of whether one considers the 95th percentile or the maximum values at each time interval.

Discussion and Summary

The three areas did not exhibit identical trends in annoyance reactions over the two-year period. In Areas I and II there was little change in the proportion of respondents who noticed the odor (88.6% compared to 86.9%), but, on the average they noticed the odor less frequently. A larger proportion of those who noticed the odor were bothered by it, but they were bothered to a smaller extent and less often.

On the other hand, in Area III, the area with the least presumptive exposure to the odors, the trends were somewhat different. There appears to have been an increase in the proportion of respondents who noticed the odor, and they tended to notice it more frequently. A larger proportion of those who noticed the odor were bothered both to a greater extent and more often. This opposing trend over time in Area III results in a difference in the relationship between areas in 1971 when compared with that which had been observed in 1969.

Area differences within each year were evaluated by using cumulative proportions because of the difficulty of interpreting shifts between individual frequency and extent categories. The expected area differences (based on presumptive exposure to odor) occurred in both 1969 and 1971 for the frequency with which odor is noticed. That is, in both years respondents in Area I tended to notice the odor most frequently and respondents in Area III tended to notice the odor least frequently. However, in 1971, although both Areas II and III were consistently lower than Area I in the extent and frequency with which the respondents were bothered, Area III no longer was consistently lower than Area II.

Compared with 1969, the proportion of individuals who mentioned pulp mill odors spontaneously in 1971 show an increase in Area I, but a decrease in Areas II and III. An increase occurred in the proportion of respondents reporting they were "a little" or "not at all bothered" who had taken action concerning the odor.

Exposure measurements made by dynamic olfactometry indicate that the presumptive area gradient based on distance from the pulp mills and location with respect to prevailing wind patterns was not confirmed in 1971 as it had been in 1969. There are several factors which should be considered in evaluating this apparent change. First, the period of sampling was not identical in both years. The sampling in 1969 was carried out during three two-week periods in June, July and August, while in 1971, the sampling took place during a single two-week period in September. The differences in results could be attributable to a difference in wind patterns. It may also be of some relevance that there were fewer observations covering a shorter time period in 1971 than in 1969, resulting in a greater effect of random variation. The 1971 data, therefore, were intended largely to confirm that the area differences detected in 1969 had not changed significantly. The second factor to be considered, and this is relevant in relation to the annoyance reactions as well as to the olfactometry measurements, is the replacement of Area III as originally delineated in 1969, by an adjacent area. As explained earlier, this was necessary to avoid resampling the respondents used in the 1969 survey. It is possible, although unlikely, that the exposure of the new Area III is substantially difference from the exposure of the old Area III and that it does not, in fact, bear the same exposure relationship to Areas I and II. In either case, it is noteworthy that the apparent change in the relationships of the three areas with respect to olfactometry measurements appears to be reflected by the annoyance reactions although not by the proportion of respondents who reported noticing the odors.

The possible effects of selective migration should not be ignored. For example, the area of least exposure to the odor might tend to attract individuals who are particularly sensitive to it.

Table 1

DESCRIPTION OF POPULATION SAMPLES BY AREA AND SEX

Eureka, 1969, 1971

	AREA I			AREA II			AREA III		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
	1969								
Sample Size	59	26	33	59	24	35	56	28	28
Respondents	52	22	30	55	23	32	51	25	26
Nonrespondents	3	1	2	4	1	3	1	1	0
Refusals	1	0	1	4	1	3	1	1	0
Unable to locate	2	1	1	0	0	0	0	0	0
Dwelling unit unoccupied	4	3	1	0	0	0	4	2	2
	1971								
Sample Size	51	24	27	52	24	28	54	22	32
Respondents	45	20	25	47	20	27	48	20	28
Nonrespondents	5	3	2	3	2	1	2	0	2
Refusals	3	1	2	2	1	1	1	0	1
Unable to locate	2	2	0	1	1	0	1	0	1
Dwelling unit unoccupied	1	1	0	2	2	0	4	2	2

Table 2

PERCENT NOTICING PULP MILL ODOR BY FREQUENCY WITH WHICH NOTICED AND AREA

Eureka 1969, 1971

	1969				1971			
	Total	I	II	III	Total	I	II	III
Total Number of Observations	158	52	55	51	132	45	45	42
Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Every day	12.0	23.1	12.7	0.0	8.3	13.3	6.7	4.8
At least once a week	37.3	57.7	41.8	11.8	32.6	48.9	33.3	14.3
At least once a month	17.1	9.6	12.7	29.4	24.2	26.7	31.1	14.3
Less often[1]	13.3	3.8	12.7	23.5	12.9	6.7	11.1	21.4
Not at all	20.3	5.8	20.0	35.3	22.0	4.4	17.8	45.2

[1] Includes ''don't know how often''.

Table 3

PERCENT BOTHERED BY PULP MILL ODOR BY EXTENT TO WHICH BOTHERED

Eureka 1969, 1971

	1969				1971			
	Total	I	II	III	Total	I	II	III
Total Number Reporting That Odor Was Noticed	126	49	44	33	103	43	37	23
Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Very much bothered	24.6	30.6	29.5	9.1	23.3	25.6	21.6	21.7
Moderately bothered	16.7	22.4	9.1	18.2	32.0	39.5	24.3	30.4
A little bothered	27.0	24.5	29.5	27.3	34.0	23.3	43.2	39.1
Not bothered at all[1]	31.7	22.4	31.8	45.5	10.7	11.6	10.8	8.7

[1] Includes those who did not know how much they were bothered.

Table 4

PERCENT BOTHERED BY PULP MILL ODOR BY FREQUENCY WITH WHICH BOTHERED

Eureka 1969, 1971

	1969				1971			
	Total	1	II	III	Total	I	II	III
Total Very Much or Moderately Bothered	52	26	17	9	57	28	17	12
Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Often (several times a week)	26.9	34.6	29.4	0.0	15.8	17.9	11.8	16.7
Occasionally (weekly)	55.8	61.5	64.7	22.2	43.9	46.4	47.0	33.2
Seldom (less often or don't know)	17.3	3.8	5.9	77.8	40.4	35.7[a]	41.1	50.0

[a] Includes 2 respondents frequency unknown.

Table 5

SPONTANEITY OF MENTION OF PULP MILL ODOR BY EXTENT TO WHICH BOTHERED

Eureka 1969, 1971

	AREA I		AREA II		AREA III	
	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered
	1969					
Total Number of Respondents	26	26	17	38	9	42
Spontaneous mention of pulp mill odor	20	7	8	3	1	1
Semi-probed mention of pulp mill odor	6	16	9	21	7	21
Probed mention of pulp mill odor	0	1	0	3	1	2
No mention of pulp mill odor	0	2	0	11	0	18
	1971					
Total Number of Respondents	28	17	17	28	12	30
Spontaneous mention of pulp mill odor	17	3	12	4	3	5
Semi-probed mention of pulp mill odor	11	12	5	15	8	7
Probed mention of pulp mill odor	0	0	0	1	1	0
No mention of pulp mill odor	0	2	0	8	0	18

Table 6

ACTION BY EXTENT TO WHICH BOTHERED BY PULP MILL ODOR

Eureka 1969, 1971

	AREA I		AREA II		AREA III	
	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered
	1969					
Total	26	26	17	38	9	42
Took action	16	1	5	0	3	0
Thought of taking action	1	0	1	0	1	0
No action	9	25	11	38	5	42
	1971					
Total	28	17	17	28	12	30
Took action	11	5	9	6	3	8
Thought of taking action	1	2	1	1	3	1
No action	14	9	7	21	6	21
Not asked	2	1	0	0	0	0

X^2 TESTS OF BACKGROUND VARIABLES
(One degree of freedom)

Eureka 1969, 1971

	1969	1971
Sex		
Male vs. female	2.06	1.34
Age		
<50 vs. 50+	10.88**	7.37**
Marital status		
Married vs. other	0.53	0.12
Occupation		
White collar vs. blue collar/professional	1.28	0.48
Job associated with mills (respondent or spouse) No vs. yes	0.01	5.55*
General attitude toward odor		
Annoyed vs. not annoyed	40.66**	35.23**
Attitude toward pulp mills		
Bad vs. good	18.96**	7.32**
General attitude toward noise		
Annoyed vs. not annoyed	0.14	2.61
Estimation of odor problem in Eureka		
Greater than other cities its size vs. other	30.73**	13.96**
Estimation of noise problem in Eureka		
Less than other cities its size vs. other	0.54	0.03
Attitude of authorities toward air pollution		
Too little concern vs. other	26.49**	20.01**
Household structure		
Children vs. adults only	5.88*	5.46*
Satisfaction with community		
Things other than pulp mill odor don't like vs. none	0.01	0.04
Housing index		
1-2 vs. 3-5 (see appendix)	7.02**	1.79
Concern about other community problems		
At least one other rated serious vs. other	0.65	0.74
Exposure (hours/day)		
Six or less vs. other	0.00	0.25
How long in area		
Same area before mills vs. other	0.01	2.27

* Significant at 5% level.

** Significant at 1% level.

Note: Underlined categories have a larger proportion of respondents who were ''very much or moderately bothered'' in both years.

Table 8

PROPORTION OF RESPONDENTS VERY MUCH OR MODERATELY BOTHERED IN EACH AREA WITHIN STRATA OF VARIABLES SHOWING SIGNIFICANT χ^2 VALUES

Eureka, 1969

	I		II		III	
	Number of Respondents	Percent Very Much or Moderately Bothered	Number of Respondents	Percent Very Much or Moderately Bothered	Number of Respondents	Percent Very Much or Moderately Bothered
Age						
< 50 years	37	64.9	28	39.3	29	20.7
≥ 50 years	15	13.3	27	22.2	22	13.6
General attitude toward odor						
Annoyed	27	74.1	29	58.6	22	36.4
Not Annoyed	25	24.0	26	0.0	29	3.4
Attitude toward pulp mills						
Good	42	42.9	42	16.7	45	15.6
Bad	10	80.0	13	76.9	6	33.3
Attitude of authorities toward air pollution						
Too little concern	23	78.3	21	61.9	16	25.0
Other	29	27.6	34	11.8	35	14.3
Estimation of odor problem						
Greater than other cities	15	80.0	13	84.6	10	40.0
Other	37	37.8	42	14.3	41	12.2
Household structure						
Adults only	18	16.7	36	30.6	25	20.0
Children	34	67.6	19	31.6	26	15.4
Housing index[1]						
1-2	23	34.8	33	21.2	27	14.8
3-5	29	62.1	22	45.5	24	20.8

PROPORTION OF RESPONDENTS VERY MUCH OR MODERATELY BOTHERED IN EACH AREA WITHIN STRATA OF VARIABLES SHOWING SIGNIFICANT χ^2 VALUES

Eureka, 1971

	I		II		III	
	Number of Respondents	Percent Very Much or Moderately Bothered	Number of Respondents	Percent Very Much or Moderately Bothered	Number of Respondents	Percent Very Much or Moderately Bothered
Age						
< 50 years	20	55.0	18	27.8	17	23.5
50+	25	68.0	27	44.4	25	32.0
Job associated with mills						
Yes	5	40.0	6	0.0	8	12.5
No	40	65.0	39	43.6	34	32.4
General attitude toward odor						
Annoyed	27	88.9	22	54.6	22	54.6
Not annoyed	18	22.2	23	21.7	20	0.0
Attitude toward pulp mills						
Good	40	57.5	39	30.8	36	25.0
Bad	5	100.0	6	83.3	6	50.0
Estimation of odor problem in Eureka						
Greater than other cities its size	12	83.3	13	69.2	10	60.0
Other	33	54.6	32	25.0	32	18.8
Attitude of authorities toward odor						
Too little concern	22	81.8	12	66.7	11	54.6
Other	23	43.5	33	27.3	31	19.4
Household structure						
Adults only	27	51.8	29	31.0	25	20.0
Other	18	77.8	16	50.0	17	41.2

Table 10

PERCENT MEASURABLE ODOR DETECTIONS
(Odor Frequency)

Eureka 1969, 1971

TIME OF DAY	AREA I		AREA II		AREA III	
	1969	1971	1969	1971	1969	1971
Total 0800-1630						
Number of Observations	564	190	846	285	1128	376
Percent With Odor	37.4	19.5	14.1	6.0	5.9	13.3
0800-1130						
Number of Observations	256	85	384	123	512	172
Percent With Odor	23.4	4.7	13.5	3.3	3.5	7.0
1200-1630						
Number of Observations	308	105	462	162	616	204
Percent With Odor	49.0	31.4	14.5	8.0	8.0	18.6

Table 11

DIURNAL MALODOR CONCENTRATION AT 95th PERCENTILE BY AREA AND TIME (as ppb CH_3SH)

Eureka 1969, 1971

TIME OF DAY	AREA I		AREA II		AREA III	
	1969	1971	1969	1971	1969	1971
0800	5.9	4.1	7.2	N.D.	N.D.	4.2
0830	5.9	N.D.	1.0	N.D.	N.D.	3.4
0900	3.1	N.D.	16.5	N.D.	N.D.	N.D.
0930	6.5	N.D.	1.9	N.D.	N.D.	N.D.
1000	7.6	N.D.	N.D.	N.D.	N.D.	N.D.
1030	3.6	N.D.	17.6	N.D.	0.6	N.D.
1100	15.1	N.D.	3.9	N.D.	2.0	13.5
1130	4.1	3.9	10.4	15.3	3.8	N.D.
1200	4.1	9.0	8.4	N.D.	1.1	N.D.
1230	16.9	2.0	2.4	N.D.	2.6	8.6
1300	5.0	4.8	2.8	6.6	2.6	N.D.
1330	18.0	9.9	21.1	N.D.	N.D.	0.4
1400	12.3	13.6	2.6	3.8	N.D.	N.D.
1430	21.2	2.7	N.D.	N.D.	8.0	7.3
1500	17.1	21.0	9.0	3.4	N.D.	15.0
1530	9.5	N.D.	N.D.	8.7	N.D.	8.8
1600	9.7	9.7	N.D.	1.1	7.3	10.4
1630	30.1	12.8	5.7	N.D.	N.D.	14.5

Table 12

MAXIMUM MALODOR CONCENTRATION DETECTED*
BY AREA AND TIME
(as ppb CH_3SH)

Eureka 1969, 1971

SAMPLING INTERVAL BEGUN AT	AREA I		AREA II		AREA III	
	1969	1971	1969	1971	1969	1971
0800	8.9	5.1	4.4	N.D.	N.D.	4.2
0830	12.9	N.D.	2.4	N.D.	5.1	5.1
0900	11.4	N.D.	28.2	N.D.	N.D.	N.D.
0930	52.5	N.D.	3.8	N.D.	N.D.	N.D.
1000	59.2	N.D.	N.D.	N.D.	N.D.	N.D.
1030	6.4	N.D.	38.9	N.D.	3.2	N.D.
1100	24.7	N.D.	5.5	N.D.	2.4	16.9
1130	5.6	6.5	16.5	16.9	5.6	N.D.
1200	10.1	17.9	31.2	N.D.	1.4	N.D.
1230	38.6	5.0	2.9	N.D.	6.0	9.8
1300	33.3	7.9	5.0	9.7	7.1	5.1
1330	19.7	11.3	170.7	N.D.	1.4	2.2
1400	28.1	16.5	23.9	6.3	N.D.	N.D.
1430	249.6	2.8	0.9	N.D.	21.9	47.8
1500	47.1	14.8	12.6	3.4	1.6	20.6
1530	16.6	N.D.	1.2	9.1	N.D.	9.9
1600	26.0	11.5	N.D.	11.1	23.1	11.6
1630	239.4	14.1	16.1	3.8	N.D.	15.4

* In each case the concentration ranged from none detected to the maximum shown.

N.D. = none detected which means less than 2 x minimum O.T. of the observer - essentially 0.

Table 13

SUMMARY OF DIURNAL OLFACTOMETRY MEASUREMENTS

Eureka 1969, 1971

	AREA I		AREA II		AREA III	
	1969	1971	1969	1971	1969	1971
Percent of 95th percentiles which were measurable odor detections[1]	100.0	61.1	77.8	33.3	44.4	55.6
Percent of maximum values which were measurable odor detections[2]	100.0	61.1	88.9	38.9	61.1	61.1
Mean of measurable odor detections at 95th percentile averaged over all time intervals	10.9	8.5	7.9	6.5	3.5	8.6
Mean of measurable odor detections at the maximum averaged over all time intervals	49.4	10.3	22.8	7.3	3.0	13.5

[1] See Table 11. This percent represents the proportion of the 18 time intervals for which the 95th percentile was at a measurable level of odor detection.

[2] See Table 12. This percent represents the proportion of the 18 time intervals which had measurable maximum values.

Table 14

CHANGE IN MAXIMUM AND 95TH PERCENTILE VALUES FOR HALF HOUR TIME INTERVALS BETWEEN 1969 AND 1971

Eureka

	AREA I	AREA II	AREA III
Maximum			
Number of time intervals showing increase	2	4	8
Number of time intervals showing no change	0	1	5
Number of time intervals showing decrease	16	13	5
95th Percentile			
Number of time intervals showing increase	3	5	9
Number of time interval showing no change	1	2	4
Number of time intervals showing decrease	14	11	5

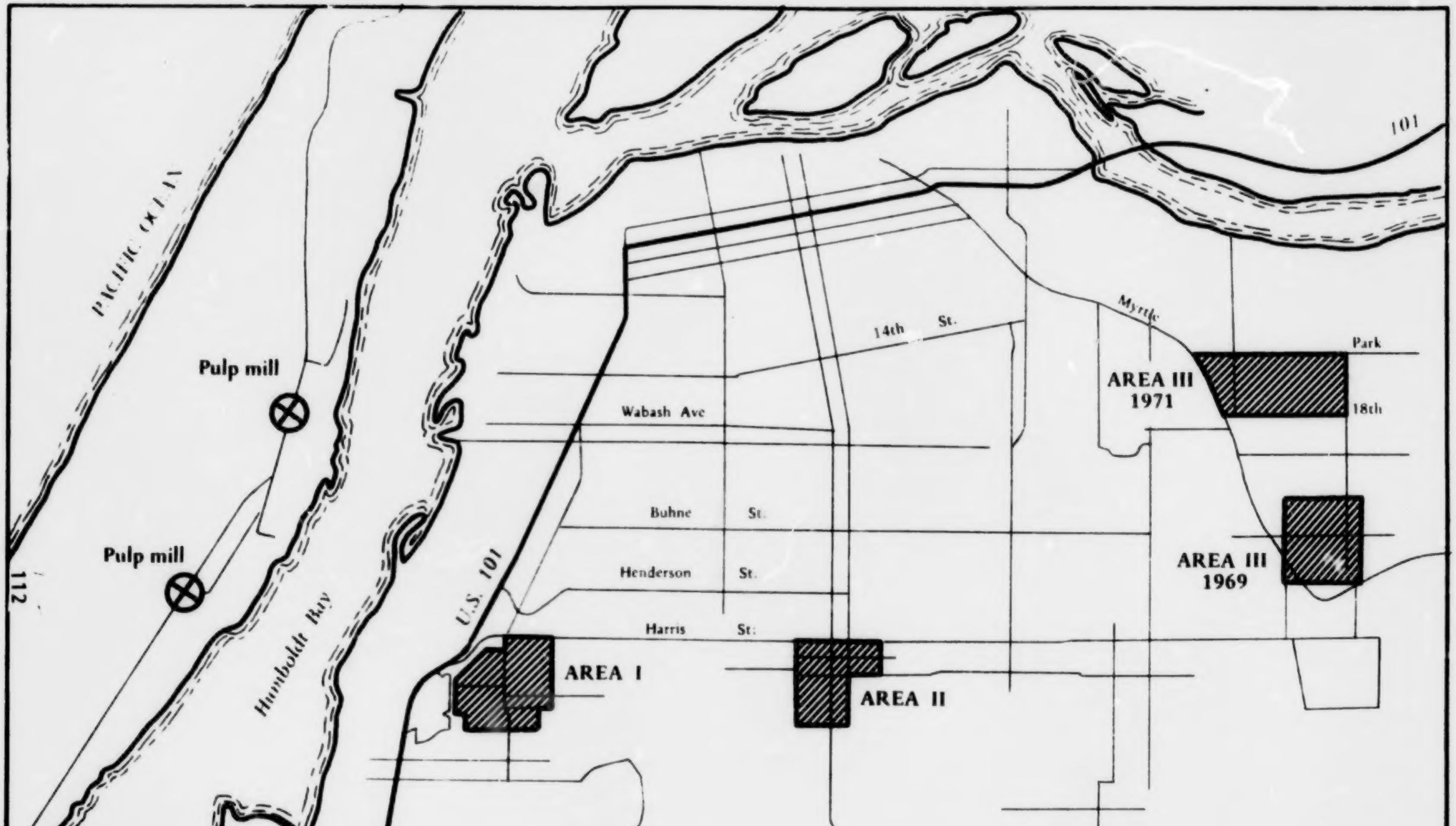

PACIFIC OCEAN
Pulp mill
Pulp mill
Humboldt Bay
U.S. 101
101
Myrtle
14th St.
Park
18th
AREA III
1971
Wabash Ave
Buhne St.
Henderson St.
Harris St.
AREA III
1969
AREA I
AREA II
EUREKA, CALIFORNIA
1969, 1971
Scale
0.0
Mile

Figure I

TRENDS IN PERCENT NOTICING PULP MILL ODOR
BY FREQUENCY WITH WHICH NOTICED AND AREA
EUREKA, 1969, 1971

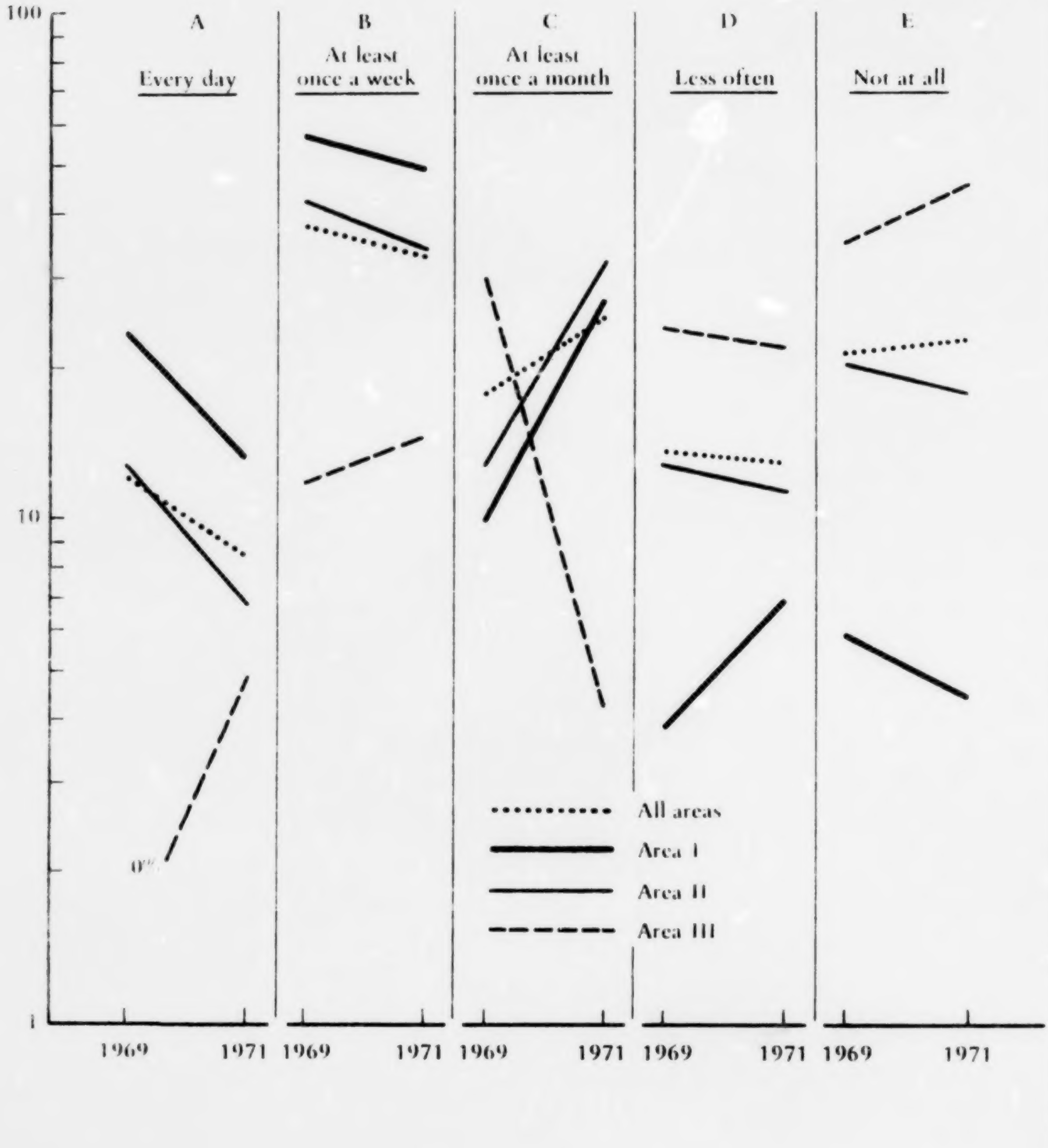


Figure 11

AREA COMPARISONS BY YEAR
FREQUENCY WITH WHICH PULP MILL ODOR IS NOTICED
(CUMULATIVE PERCENTS)
EUREKA, 1969, 1971

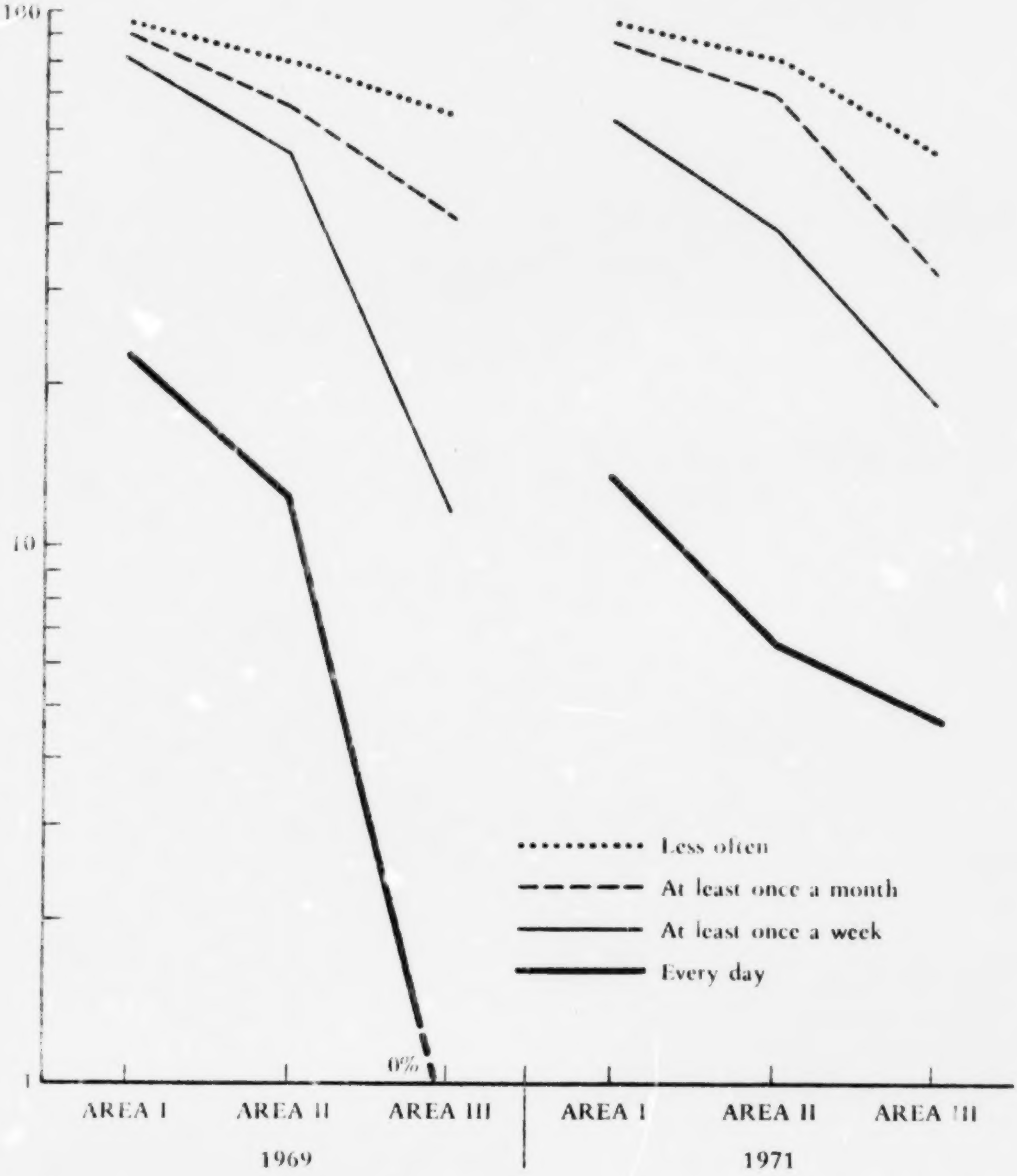
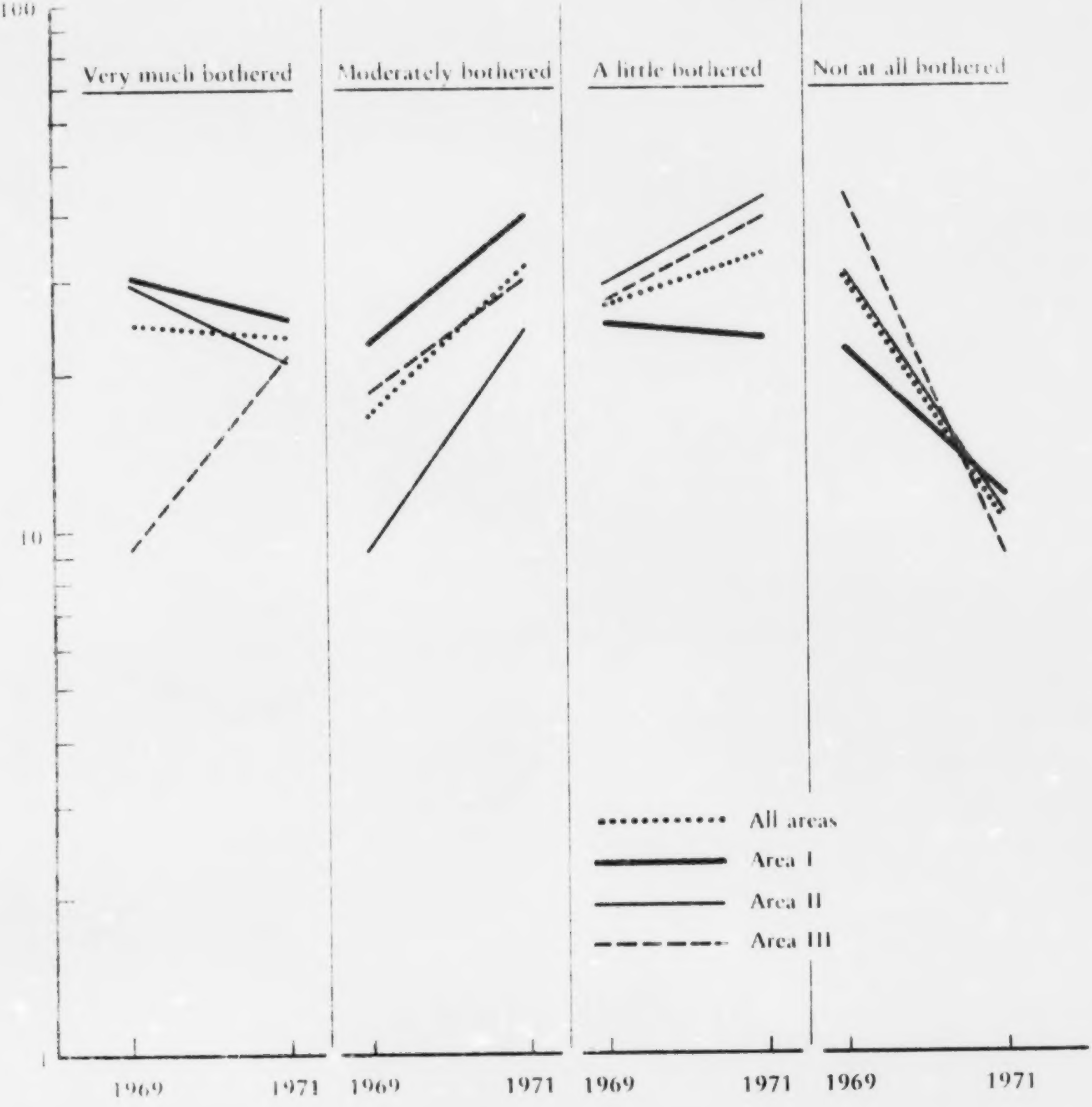


Figure III

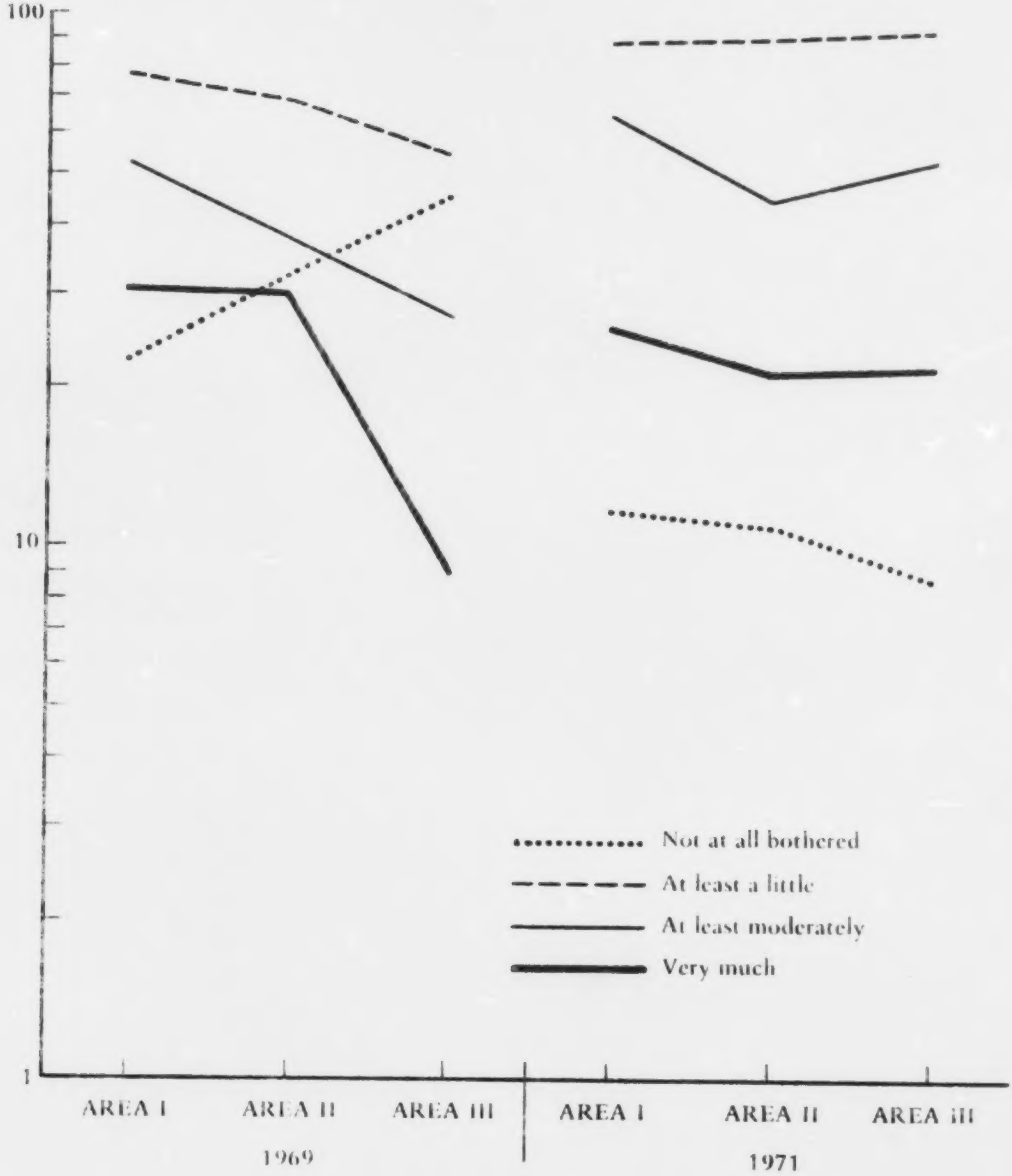
TRENDS IN PERCENT BOTHERED BY PULP MILL ODOR
BY EXTENT TO WHICH BOTHERED AND AREA
EUREKA, 1969, 1971



Note: Percents based on total who noticed the odor.

Figure IV

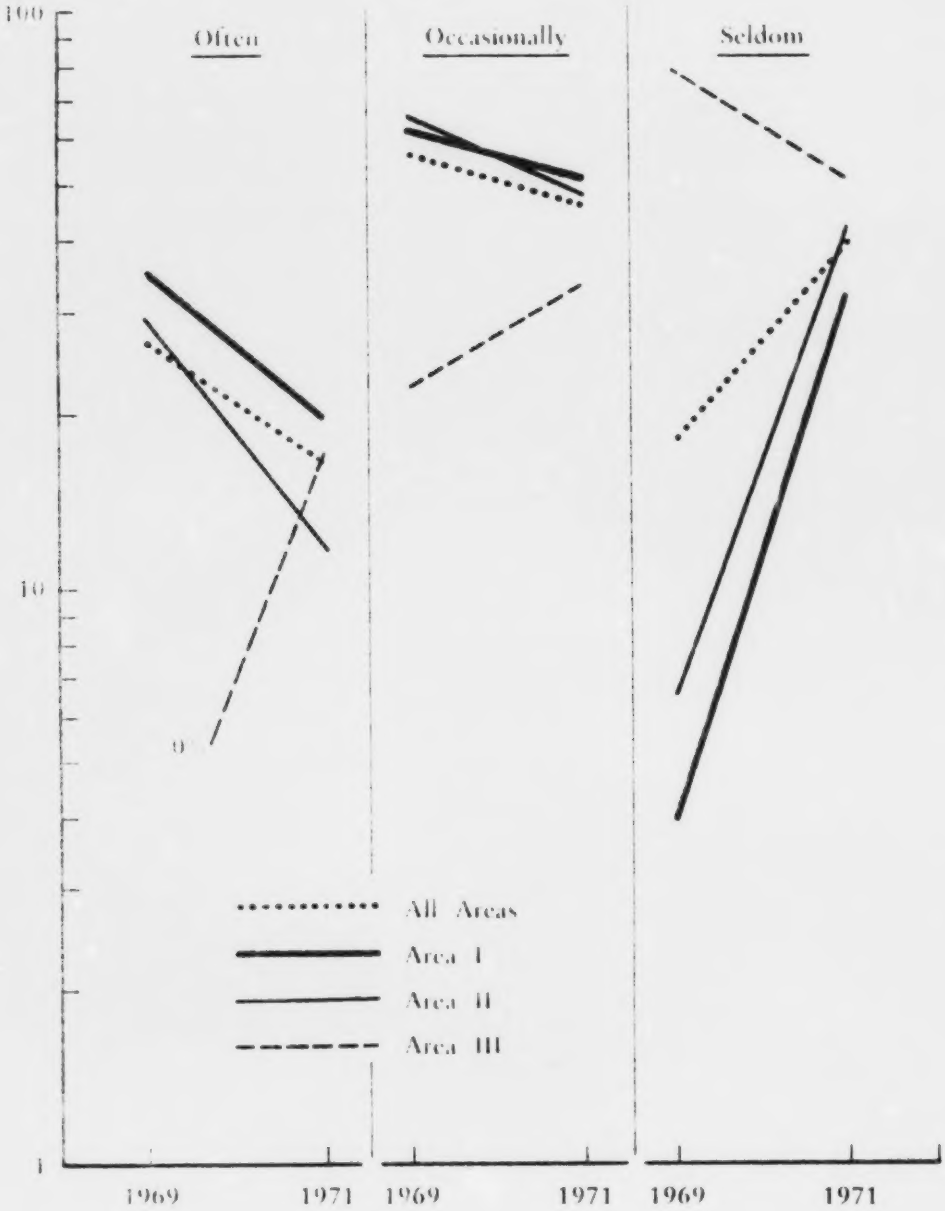
AREA COMPARISONS BY YEAR
EXTENT TO WHICH BOTHERED BY PULP MILL ODOR
(CUMULATIVE PERCENTS)
EUREKA, 1969, 1971



Note: Percents based on total who noticed the odor.

Figure V

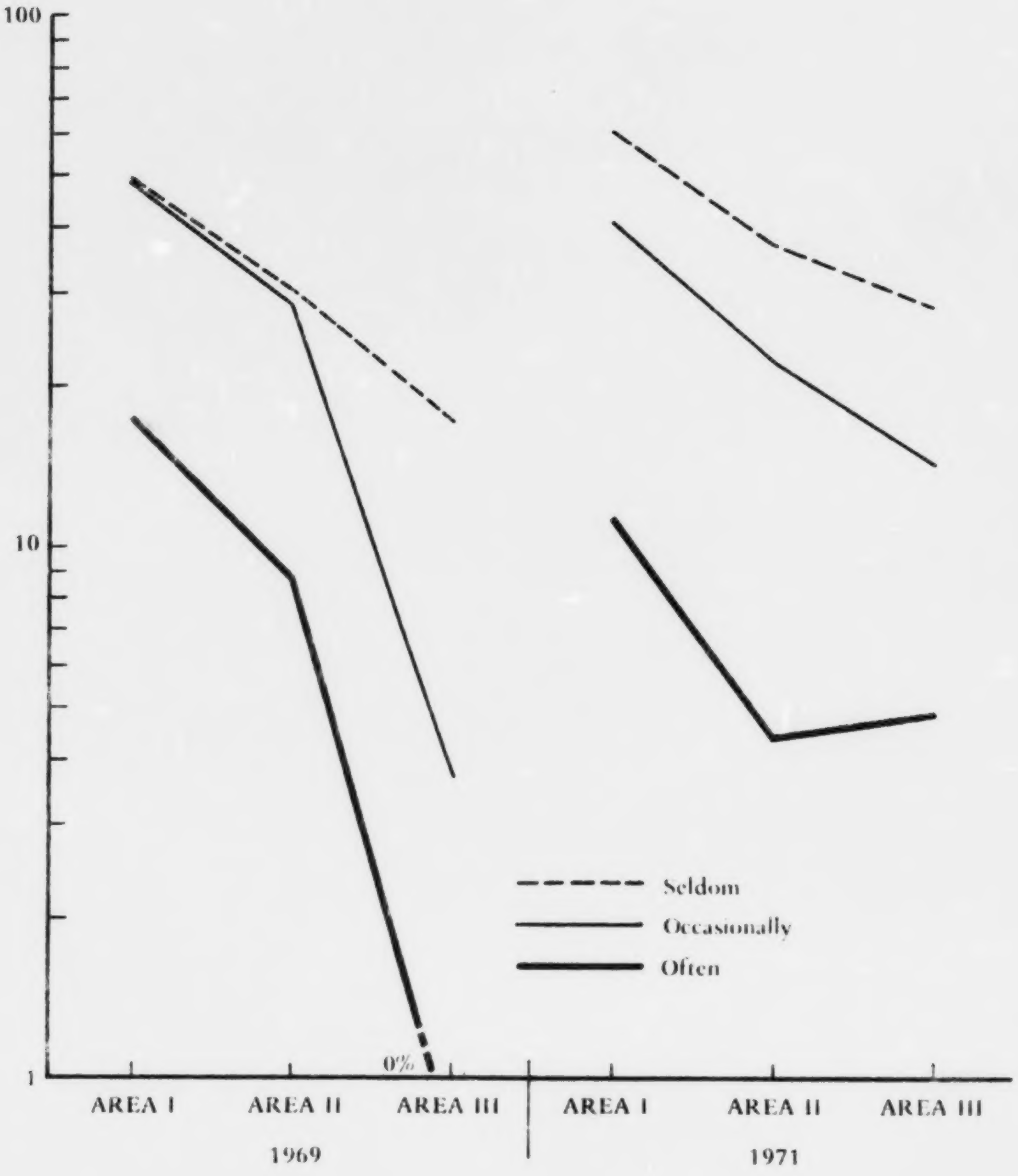
TRENDS IN PERCENT
VERY MUCH OR MODERATELY BOTHERED BY PULP MILL ODOR
BY FREQUENCY WITH WHICH BOTHERED AND AREA
EUREKA, 1969, 1971



Note: Percents based on total who were very much or moderately bothered by the odor.

Figure VI

AREA COMPARISONS BY YEAR
FREQUENCY WITH WHICH BOTHERED BY PULP MILL ODOR
FOR RESPONDENTS VERY MUCH OR MODERATELY BOTHERED
(CUMULATIVE PERCENTS)
EUREKA, 1969, 1971



Note: Percents based on total who noticed the odor.

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MD:qjjl-14 & qkkl-7

EUREKA PULP MILL STUDY

APPENDIX

Definitions of Analytic and Background Variables

Table 2

Positive responses to two questions were used to measure the frequency with which pulp mill odor was noticed by the respondent:

A. "Have you noticed odors from industries here at home during the last three months? What industries?" (Pulp mills were not specifically mentioned to the respondent. See page 10 of the questionnaire.)

B. "Some people here in Eureka have been complaining about odors from the pulp mills. Here in your house have you noticed the odors during the last three months?" (This question was asked only of respondents who had not already mentioned pulp mill to the question concerning odors from industry. See page 12 of the questionnaire.)

For each question, respondents who gave a positive response were asked:

C. "How often? Is it every day, at least once a week, at least once a month, or less often?" The "not noticed at all" category included individuals who did not know whether they had noticed the pulp mill odor. (See pages 10 and 12 of the questionnaire.)

Table 3

Individuals who had given positive answers to either questions A or B (above) were classified according to the extent bothered by pulp mill odor according to responses to the following question:

D. "Would you say it has bothered you only a little, moderately, very much, not at all?" (See pages 10 and 12 of the questionnaire.)

Table 4

Respondents who had indicated on question D that they were very much or moderately bothered were tabulated by "frequency with which bothered" on the basis of answers to question C (above) and an additional question:

E. "How often has it bothered you? Is it almost every time, about half the time, less often?"

The definitions of "frequency with which bothered" in terms of responses to questions C and E are shown below:

How Often Noticed (Question C)	How Often Bothered (Question E)	
	Almost every time or about half the time	Less often or don't know
Every day	Often	Occasionally
At least once a week	Occasionally	Seldom
At least once a month	Seldom	Seldom
Less often or don't know	Seldom	Seldom

Table 5

Respondents were tabulated according to whether they mentioned the pulp mill odor "spontaneously", gave a "semi-probed" response, or gave a "probed" response, defined as follows:

"Spontaneous mention of pulp mill odors" was defined as mention of pulp mill odors in response to the following questions:

F. "What are some of the things you don't like about living here?"

G. "Have you ever felt like moving away from this residential area?" If yes, "when you have felt like moving away, what has the reason been?"

H. "If you could find a similar apartment (house) which would not be more expensive in another residential area, would you like to move there?" If yes, "why would you like to do this?"

I. "Is there anything here in the community that you think is harmful for you or your family?" If yes, "what is this?"

These questions occur early in the questionnaire before either pulp mill odors or odors from other industry have been mentioned by the interviewer. (See pages 4-6 of the questionnaire.)

"Semi-probed mention of pulp mill odors" was defined as mention of pulp mill odors in response to the following question if the respondent had not already mentioned odor "spontaneously":

J. "Have you noticed odors from industries here at home during the last three months?" If yes, "what industries?"

This question occurred before the interviewer had specifically mentioned pulp mill odors. (See page 10 of the questionnaire.) Responses mentioning pulp mill odor were called "semi-probed" only if the respondent had not previously mentioned pulp mill odors.

"Probed mention of pulp mill odors" was defined as a positive response to the following question, which was asked only if respondent had not already given a "probed" or "semi-probed" pulp mill response:

K. "Some people here in Eureka have been complaining about odors from the pulp mills. Here in your house have you noticed the odors during the last three months?" (See page 12 of the questionnaire.)

Table 6

Data shown on Table 6 were tabulated from positive responses with mention of pulp mill odor to the following questions:

L. "Have you ever thought of requesting, or have you actually requested some authority or agency to take action concerning any of these problems, e.g., by writing or phoning an official, signing a petition, or attending a meeting?" If so, "what problem was it?" (See page 8 of the questionnaire.)

M. "Have you ever felt like moving away from this residential area?" If yes, "when you have felt like moving away, what has the reason been?" (See page 5 of the questionnaire.)

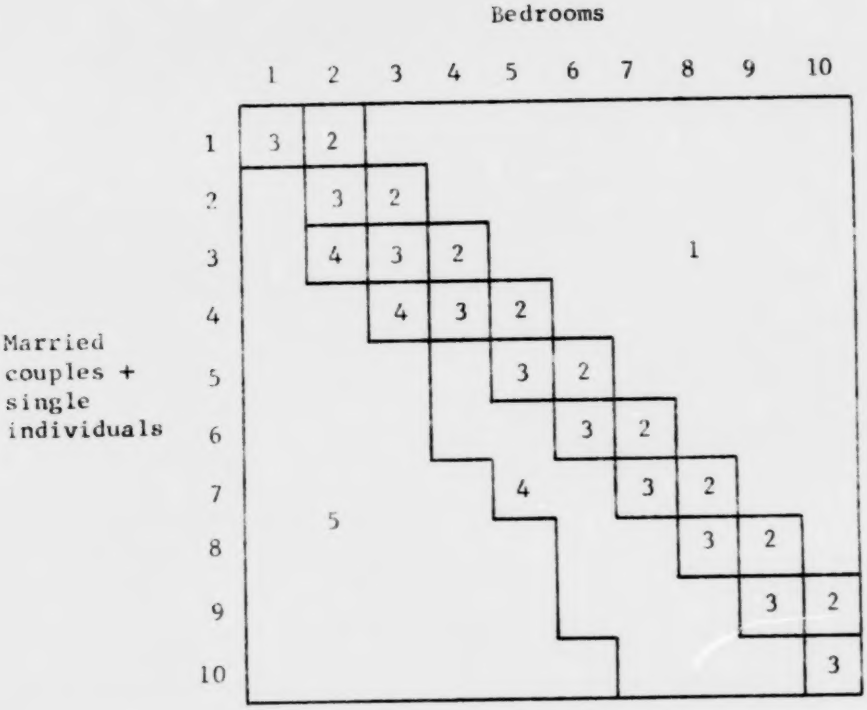
Tables 7-9

Background Variables

Attitude toward authorities was based on question 60, page 15 of the questionnaire.

Satisfaction with community was based on questions 5, 7, and 8, pages 4 and 5 of the questionnaire. Individuals who indicated that there were things other than pulp mill odor that they did not like about the residential area, were tested against all others. Those who didn't know whether to rate the community good, fair, or poor were included in the latter category.

Housing index was derived from the number of bedrooms in the household and the number of married couples, single adults and children. Households coded 1-2 as indicated below were tested against those coded 3-5.


Bedrooms
Married couples + single individuals

SECTION VI-D

Health Effects of Pulp Mill Odor in Anderson, California

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Bureau of Occupational Health and
Environmental Epidemiology

Supported in part by a contract with
Environmental Protection Agency

INTRODUCTION

During late summer of 1970 the California Air and Industrial Hygiene Laboratory carried out an environmental survey designed to measure the presence and intensity of pulp mill odor in the Anderson-Cottonwood area area of northern California.[1] In spite of several limitations (discussed below) this geographic location seemed appropriate for carrying out a health survey in relation to exposure to pulp mill odor. A previous study in a northern coastal area of California (Eureka) had been conducted during the summer of 1969 to estimate annoyance reactions to pulp mill odor and to test their relationship to several measurements of exposure to odor.[2] However, in the Eureka study questions concerning physical health were asked only of respondents who indicated that they were "very much" or "moderately" bothered by the odor. Furthermore, the health question was phrased "Do you get any of the following symptoms when you are bothered by the odors?" The results have limited value for comparing the health of individuals experiencing different levels of exposure to odor since responses were not obtained from individuals who:

1. were not "very much" or "moderately" bothered by the odor;
2. lived in relatively odor-free areas;
3. did not attribute their symptoms to the odor.

In addition, the responses might have been biased because of the respondents' attitudes toward the odor or their desire to force community action against the source. A better measure of health ought to be obtained by a general health survey of all members of a population sample chosen so as to represent varying exposures to odor. The questionnaire or interview should make no specific reference to the odor although the respondent might be given an opportunity to attribute his symptoms to odor.

STUDY AIMS

The specific aim of the Anderson study was to determine whether community exposure to odor from pulp mills has any effect on health measurable by the type of personal interview used. Implicit in the design of such a study is the measurement and "control" (during analysis) of other relevant factors which may affect the health responses to the questionnaire. Studies previously done by other investigations have demonstrated that annoyance reactions and medical symptoms may occur in communities exposed to industrial odor.[3-6]

METHODOLOGY AND MATERIALS

Description of Study Area

According to an estimate made in 1967, the incorporated city of Anderson has a population of 6,137 persons. The sampling frame for the study was comprised of 1,246 households, including most of the incorporated area as well as some unincorporated districts. The town is located at the extreme north of the Sacramento Valley. Unlike Eureka, which experiences the moderating climatic effect of the Pacific Ocean, Anderson is exposed to seasonal extremes of temperature and rainfall. Also in contrast to Eureka, which is exposed to a seasonal shift in wind direction, Anderson is characterized year round by winds from the northeast in the morning, shifting to the southeast in the afternoon.

As mentioned above, several limitations of the area were recognized with respect to population surveys. These included the relatively small size of the community, the small proportion of the population which lives near the pulp mill, and the predominantly rural character and modest housing of the area closest to the mill compared with the areas with less exposure to the pulp mill odors.

Selection of Exposure Areas

Before the environmental survey, three areas of Anderson had been defined as representing three levels of presumptive exposure to odor on the basis of topography, prevailing winds, and distance from the mill. (Figure I) These were subsequently confirmed by the exposure measurements made by dynamic olfactometry. Although these measurements were made in August and the health survey was carried out in November, the seasonal factor was not felt to be of importance because the prevailing wind pattern is essentially the same all year round. Because of the diurnal wind pattern measurements in Cottonwood (south of the mill) were made in the morning, and measurements in Anderson (north of the mill) were made only in the afternoon.

As a result of the environmental survey, two areas farthest from the mill in the Anderson sector were selected to represent moderate and slight exposure to the odor. The areas closest to the mill in both the Anderson and Cottonwood sectors were combined and expanded slightly to represent the greatest exposure to the odor.

Exposure Measurements

The exposure to odor in the three areas was estimated by dynamic olfactometry. The measurements are based on the "odor dilution factor," which is the ratio of ambient air (air to which the community is exposed) to odorless air at which a trained observer just detects malodor. This is converted to the equivalent of parts per billion of a specific odorant by multiplying by the odor threshold of each observer, which is the ratio of a known dilution of a specific odorant to odorless air at which the observer just detects the malodor.

The sensitivity of the method is a function of the observer's odor threshold and the lowest dilution of odorant to odorless air that can be measured on the olfactometer. In order to sample the ambient air adequately, daily observations were obtained during the period August 24 through September 4, 1970, excluding the weekend of August 29-30. Two observers were exposed to the ambient air at several sites in each of the three areas at half-hourly intervals during the day. The sampling sites, the method of sampling the ambient air, and the instrumentation and technique of using the olfactometer are described in detail elsewhere.[7,8] The odor threshold of each observer was measured twice a day.

Population Sampling

Preliminary scouting of the three "exposure" areas suggested that significant differences occurred in housing and type of neighborhood, including population density. These differences implied possible differences in level of income and other social factors affecting health. It was not feasible to characterize subareas with any degree of precision, but some stratification seemed advisable. Consequently, each "exposure" area was subdivided into three subareas, one characterized predominantly by scattered rural housing, one by central town-type housing, and one by suburban tract-type housing. The rural housing was defined primarily on the basis of sparsity of settlement, but appeared to represent a relatively large proportion of housing of poor quality, frequently located on property which included farm out-buildings and livestock. The suburban tract-type housing was on the outskirts of town and was largely "California ranch" style. The housing in the central areas tended to be more modest and was located in the older, central part of town with a conventional grid pattern of streets.

The "exposure" areas will subsequently be referred to as Areas I, II and III, representing high, moderate, and low exposure to pulp mill odor, and the subareas will be designated as rural, central and tract.

Unfortunately, from the viewpoint of study design, Area I (high exposure), is sparsely populated and fell entirely within the rural subgroup. The highest rate of housing vacancy appeared to occur here. Areas II and III are comprised of all three residential subgroups.

The sample sizes shown below (Table 1) were chosen so as to permit some comparison within residential subgroups as well as between totals for each of the three areas. The high sampling ratios may have been a disadvantage because they increase the possibility of bias resulting from pre-interview discussion of the survey among prospective respondents.

A sampling frame was constructed for each subarea by listing all houses which appeared to be occupied. If houses included in the sample were found to be unoccupied at the time of interview, they were replaced by sampling randomly between the "interviewed" houses on either side.

Sampling was systematic with an independent random start in each subarea. Alternate households were designated to have a male or female respondent interviewed. If a household did not have a respondent of the designated sex, one of the other adult members was interviewed.

Questionnaire Design

The questionnaire included information regarding date of birth, sex, marital status, occupation and place of employment, length of residence in the area, pre-existing medical conditions, smoking habits, and exposure to specific industrial hazards which might affect health. The basic questions of the British Medical Research Council's Questionnaire on Respiratory Symptoms (1966)[9] were included as a measure of chronic respiratory effects. This was followed by three sets of questions concerning symptoms which it was believed might be associated with exposure to pulp mill odor. The respondent was first asked whether he had each of these symptoms frequently, occasionally, or hardly ever. For each symptom experienced frequently or occasionally, he was then asked whether there was anything in particular which seems to bring it on, or whether he had experienced it during the past two weeks. He was also asked whether he had been sick at any time during the last two weeks, and whether he would say that his health was excellent, good, fair, or poor. It proved to be cumbersome and time-consuming to ask this much detail about the symptoms on the list, but no estimate existed of the frequency of these symptoms in the general population, and we hoped to obtain adequate frequencies of positive responses to at least one of these questions to permit statistical testing of the results. It was also felt that the respondent should be given an opportunity to attribute symptoms to the pulp mill odor although the odor was not mentioned at any time during the interview. The interview was introduced to the respondent as a general health survey and no reference was made to pulp mill odor anywhere in the questionnaire. This has been found to be important in obtaining unbiased results.[10]

Interviewing

Interviewing was carried out by two part-time and four full-time interviewers, including two staff members who participated in other aspects of the survey. Training began on the Wednesday evening preceding the field work and continued through part of the following Saturday. A preliminary description of the study and run-through of the questionnaire and instructions was followed by demonstration interviews by staff members and practice interviews by staff members and trainees.

Standard training tape recordings of demonstration interviews of the MRC part of the questionnaire were also used. The most intensive part of the training consisted of one-to-one interviewing practice with members of the training staff, followed by playback of tape recordings and group discussion. The final phase of training included "real" interviews on members of a community not being included in the survey proper. Completed questionnaires were edited by staff members and discussed with the trainees.

The initial plan required each interviewer to interview the same proportion of respondents in each area, and to do about the same proportion of interviews on each day in each area. The former should have equalized interviewer differences so that they would not appear as area differences; the latter was to insure that increasing community awareness and discussion of the content of the study would occur at the same rate in all areas. In practice, it became increasingly difficult to maintain this schedule beyond the first few days of interviewing.

Each interviewer was usually seen by a staff member at least once a day for collection of completed interview schedules, assignment of new interviews, and discussion of problems. Preliminary editing of interview schedules was done on a current basis so that omissions or errors could be corrected while field work was still in progress.

Statistical Analysis

The basic hypotheses being tested are that area trends exist in health reactions, with Area I having the highest percent of respondents reporting reactions and Area III the lowest. The test used is the χ^2 for trend test described by Armitage.[11] In this application, an assumption of linearity of trend is made, and equally-spaced scores are chosen to represent each area. In addition to testing the statistical significance of the trend, one may also test for departure from trend by comparing the χ^2 for trend with the total 2 x 3 χ^2.

Other tests which could have been used to test for significant area differences include the usual total 2 x 3 χ^2, and pairwise testing of area differences using 2 x 2 χ^2 (Area I vs. Area II, Area I vs. Area III, and Area II vs. Area III). The latter method would have altered the level of significance in a manner similar to that encountered in multiple t-tests. The total 2 x 3 χ^2 test would not have given appropriate weight to consistencies in the direction of trend (Area I > Area II > Area III). Unless otherwise indicated, statistical significance refers to the 5% probability level, but this does not necessarily imply that a higher significance level was not attained.

RESULTS OF HEALTH SURVEY

The results of area comparisons for all housing subareas combined, that is, making no distinction by rural, central, or tract housing, are shown in Tables 2 through 5. Comparable results for rural subareas only (the only type of housing occurring in all three areas) are shown in Tables 6 through 9.

For the list of symptoms, totals for both sexes combined are shown for percent of respondents reporting symptoms "frequently" and "frequently or occasionally" (Tables 2 and 6). Percents reporting symptoms "frequently or occasionally", and "during the last two weeks" are shown separately by sex (Tables 3-4, 7-8) as are the percents reporting the various MRC conditions. (Tables 5 and 9). Information on symptoms within the last two weeks was obtained only for respondents who had already reported having the symptom frequently or occasionally.

For all areas combined, a statistically significantly greater percent of women than men reported nervousness, headache, insomnia, and fatigue. This occurs both for symptoms reported frequently, for those reported frequently or occasionally, and for symptoms reported during the last two weeks. These sex differences are not, however, consistent in all areas. In addition, palpitations, dizzinesss, nausea, and shortness of breath were reported frequently or occasionally by a significantly greater percent of women than men.

For all subareas combined, significant area trends occur for the percent reporting the following symptoms frequently or occasionally: Headache, among both men and women; nausea, men only; runny nose, both sexes combined; cough, men only (Table 3). Corresponding trends occurred for percents who reported the following symptoms during the last two weeks: headache, both men and women; sinus congestion, both sexes combined; runny nose, both sexes combined and men; and cough, both sexes combined (Table 4). No significant area trends were found for percents reporting symptoms only frequently. All cough and phlegm MRC symptoms show significant area trends for both sexes combined; phelgm grade 1 and 2, and persistent cough and phlegm show significant trends for men (Table 5).

Among the rural subareas, significant area trends occur for percents reporting the following symptoms frequently or occasionally: shortness of breath, men only; irritation of the nose, both sexes combined; and chest pains, men only (Table 7). Significant trends were found for the percent reporting symptoms during the last two weeks as well as frequently or occasionally for the following symptoms: shortness of breath and chest pains, men only; cough, both sexes combined (Table 8). The only significant area trend found among respondents reporting symptoms frequently was for cough reported by men. Significant trends for both sexes combined were found for the MRC cough and phlegm symptoms.

Smoking habit (having never smoked, past smoker, present smoker) was significantly related to the MRC symptoms, but among present cigarette smokers, the amount smoked did not show a significant relationship to those symptoms. Since smoking habits were found to not differ significantly by exposure area, they were not taken into account in the analysis although there were slightly higher percents of present smokers in Area I, as shown in Table 9. The possible effect of subarea was tested by combining data for Areas II and III (Area I had only rural housing) and stratifying by rural, tract, and central town housing. A significant relationship of subarea to cough and phlegm was found and suggests that some apparent exposure area differences could be due to differences in housing. However, when area comparisons were made within the rural subareas only, (the only subareas for which data are available for all three exposure areas), the same significant area trends were found for the MRC cough and phlegm symptom (Table 10).

Significant relationships were found between some of the background variables and the frequency with which some of the sixteen listed symptoms were reported. Occupation and industry showed significant relationships to nervousness, insomnia and palpitations. Marital status was significantly related to nervousness and fatigue.

Eight respondents attributed at least one symptom specifically to odor in the air; these included headache, insomnia, sinus congestion, eye irritation, burning or irritation of the nose, runny nose and cough. An additional seventeen respondents attributed at least one symptom to air pollution without specifically mentioning odor.

RESULTS OF EXPOSURE MEASUREMENTS

The results of the exposure measurements made by dynamic olfactometry are summarized in Tables 11 - 12. The area gradient which was predicted on the basis of distance from the pulp mill is confirmed by the percents of measurable odor detections shown by area in Table 11.

The area gradient is not as well supported by the maximum values detected in each half hour interval although Area I clearly has a preponderance of higher values than Areas II and III.

DISCUSSION AND SUMMARY

Several symptoms show some suggestion of being related to exposure to pulp mill odor. These include headache, nausea, sinus congestion, runny nose, and cough for all subareas combined; and shortness of breath, irritation of the nose, cough, and chest pains for rural subareas only. Significant area differences were also found for cough and phlegm as defined by the MRC questions. It should be noted, however, that some of these results are based on relatively small numbers of observations. Furthermore, the area differences could be related to some factor other than exposure.

The significant sex differences in reported symptoms emphasize the need to make area comparisons separately by sex or to adjust for differences in the proportions of men and women in each area.

Although the area comparisons are inconclusive, they suggest that the interview used is a useful method for further studies of the health effects of exposure to pulp mill odor. Furthermore, relationships among the health variables themselves give some evidence for the validity of the questions. For example, responses to the question, "Would you say that your health in general is excellent, good, fair or poor?", showed a highly significant relationship to many of the other health questions.

The apparent effect of type of residential area indicates the importance of taking into account socio-economic variables in making area comparisons. Larger sample sizes would increase the possibility of determining the effects of the background variables.

Acknowledgements

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Table 1

TOTAL NUMBER OF HOUSEHOLDS, SAMPLE SIZE AND SAMPLING RATIOS BY EXPOSURE AREA AND HOUSING SUBAREA

	AREA I	AREA II	AREA III
Rural	Households = 115 Sampling Ratio = 1:1 Sample = 100 Male = 48 Female = 52	Households = 67 Sampling Ratio = 1:1.3 Sample = 52 Male = 24 Female = 28	Households = 154 Sampling Ratio = 1:3 Sample = 51 Male = 19 Female = 32
Central	Households = 0	Households = 232 Sampling Ratio = 1:4.6 Sampling = 45 Male = 21 Female = 24	Households = 298 Sampling Ratio = 1:5.4 Sample = 50 Male = 22 Female = 28
Tract	Households = 0	Households = 97 Sampling Ratio = 1:1.9 Sample = 50 Male = 22 Female = 28	Households = 383 Sampling Ratio = 1:7.5 Sample = 51 Male = 21 Female = 30

Table 2

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY AND FREQUENTLY OR OCCASIONALLY

ANDERSON, 1970

	FREQUENTLY				FREQUENTLY OR OCCASIONALLY			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	399	100	147	152	399	100	147	152
Nervousness	28.1	29.0	26.5	28.9	50.1	55.0	53.1	44.1
Headache	15.3	17.0	16.3	13.2	38.3	47.0	40.8	30.3
Insomnia	10.3	10.0	8.8	11.8	23.1	18.0	24.5	25.0
Fatique	14.5	14.0	12.9	16.4	38.8	44.0	35.4	38.8
Palpitations	2.5	2.0	2.0	3.3	12.5	11.0	10.2	15.8
Dizziness	3.8	5.0	3.4	3.3	16.8	15.0	15.0	19.7
Nausea	2.3	3.0	1.4	2.6	8.8	12.0	8.2	7.2
Vomiting	0.3	0.0	0.0	0.7	3.0	2.0	2.7	3.9
Sweating	8.8	9.0	8.2	9.2	18.0	23.0	15.6	17.1
Sinus Congestion	14.8	19.0	15.0	11.8	34.3	39.0	31.3	34.2
Eye Irritation	5.8	8.0	6.1	3.9	17.0	17.0	18.4	15.8
Shortness of Breath	5.8	8.0	5.4	5.9	19.5	23.0	18.4	18.4
Nose Irritation	2.5	3.0	4.1	0.7	6.8	8.0	9.5	3.3
Runny Nose	6.8	8.0	8.8	3.9	26.6	33.0	27.2	21.7
Chest Pains	4.0	7.0	2.7	3.3	10.3	12.0	10.2	9.2
Cough	5.3	11.0	2.0	4.6	23.1	30.0	21.1	20.4

Table 3

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY OR OCCASIONALLY BY SEX AND AREA

ANDERSON, 1970

	MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	177	48	67	62	222	52	80	90
Nervousness	34.5	41.7	40.3	22.6	62.6	67.3	63.8	58.9
Headache	30.5	41.7	29.9	22.6	44.6	51.9	50.0	35.6
Insomnia	14.7	10.4	19.4	12.9	29.7	25.0	28.8	33.3
Fatigue	27.1	37.5	22.4	24.2	48.2	50.0	46.2	48.9
Palpitations	7.9	6.2	10.4	6.5	16.2	15.4	10.0	22.2
Dizziness	10.1	8.3	10.4	11.3	22.1	21.2	18.8	25.6
Nausea	5.1	12.5	1.5	3.2	11.7	11.5	13.8	10.0
Vomiting	1.7	4.2	1.5	0.0	4.1	0.0	3.8	6.7
Sweating	14.7	16.7	11.9	16.1	20.7	28.8	18.8	17.8
Sinus Congestion	32.8	39.6	26.9	33.9	35.6	38.5	35.0	34.4
Eye Irritation	15.3	16.7	16.4	12.9	18.5	17.3	20.0	17.8
Shortness of Breath	14.7	18.7	13.4	12.9	23.4	26.9	22.5	22.2
Nose Irritation	5.6	8.3	7.5	1.6	7.7	7.7	11.2	4.4
Runny Nose	24.3	33.3	20.9	21.0	28.4	32.7	32.5	22.2
Chest Pain	9.6	14.6	7.5	8.1	10.8	9.6	12.5	10.0
Cough	26.0	39.6	20.9	21.0	20.7	21.2	21.2	20.0

Table 4

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY OR OCCASIONALLY AND DURING THE LAST TWO WEEKS BY SEX AND AREA

ANDERSON, 1970

	MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	177	48	67	62	222	52	80	90
Nervousness	19.2	22.9	19.4	16.1	49.1	50.0	51.2	46.7
Headache	17.5	27.1	17.9	9.7	34.7	44.2	37.5	26.7
Insomnia	10.2	6.2	11.9	11.3	21.2	23.1	17.5	23.3
Fatigue	18.1	27.1	13.4	16.1	32.9	42.3	30.0	30.0
Palpitations	2.8	0.0	3.0	4.8	7.7	7.7	7.5	7.8
Dizziness	2.3	4.2	0.0	3.2	12.6	13.5	12.5	12.2
Nausea	1.7	2.1	1.5	1.6	8.1	7.7	8.8	7.8
Vomiting	1.1	2.1	1.5	0.0	2.3	0.0	2.5	3.3
Sweating	6.2	6.2	4.5	8.1	15.3	21.2	13.8	13.3
Sinus	17.5	25.0	14.9	14.5	19.4	28.8	17.5	15.6
Eye Irritation	7.3	6.2	6.0	9.7	11.7	11.5	12.5	11.1
Shortness of Breath	7.3	10.4	7.5	4.8	14.4	17.3	15.0	12.2
Nose Irritation	2.8	4.2	3.0	1.6	3.6	3.8	5.0	2.2
Runny Nose	11.9	20.8	11.9	4.8	17.6	26.9	15.0	14.4
Chest Pain	8.5	12.5	6.0	8.1	8.1	9.6	8.8	6.7
Cough	17.5	29.2	11.9	14.5	14.4	21.2	11.2	13.3

Table 5

PERCENT OF RESPONDENTS REPORTING COUGH, PHLEGM, SHORTNESS OF BREATH, AND RECENT ILLNESS BY SEX AND AREA

ANDERSON, 1970

	MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	177	48	67	62	222	52	80	90
Cough Grade 1 or 2	17.5	22.9	17.9	12.9	11.3	15.4	11.2	8.9
Cough Grade 2	6.8	10.4	6.0	4.8	4.5	9.6	2.5	3.3
Phlegm Grade 1 or 2	16.9	25.0	17.9	9.7	9.9	17.3	7.5	7.8
Phlegm Grade 2	9.6	16.7	7.5	6.5	5.4	9.6	3.8	4.4
Persistent Cough and Phlegm	9.6	16.7	9.0	4.8	4.5	9.6	1.2	4.4
Shortness of Breath								
Grade 2 or Greater	25.4	29.2	25.4	22.6	40.5	38.5	41.2	41.1
Grade 3 or Greater	9.6	6.2	14.9	6.5	7.2	9.6	3.8	8.9
Sick Within Last 2 Weeks	12.4	12.5	10.4	14.5	69.4	78.8	75.0	58.9

Table 6

PERCENT OF RESPONDENTS REPORTING SYMPTOMS "FREQUENTLY" AND "FREQUENTLY OR OCCASIONALLY" RURAL SUBAREAS ONLY

ANDERSON, 1970

	FREQUENTLY				FREQUENTLY OR OCCASIONALLY			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	203	100	52	51	203	100	52	51
Nervousness	30.5	29.0	28.8	35.3	53.2	55.0	53.8	49.0
Headache	14.3	17.0	11.5	11.8	41.4	47.0	40.4	31.4
Insomnia	10.3	10.0	7.7	13.7	21.2	18.0	21.2	27.5
Fatigue	13.3	14.0	13.5	11.8	39.9	44.0	34.6	37.3
Palpitations	2.5	2.0	1.9	3.9	10.8	11.0	7.7	13.7
Dizziness	4.4	5.0	3.8	3.9	18.2	15.0	13.5	27.5
Nausea	2.0	3.0	0.0	2.0	10.8	12.0	9.6	9.8
Vomiting	0.0	0.0	0.0	0.0	3.4	2.0	3.8	5.9
Sweating	8.4	9.0	5.8	9.8	18.7	23.0	13.5	15.7
Sinus Congestion	15.3	19.0	11.5	11.8	36.5	39.0	25.0	43.1
Eye Irritation	6.9	8.0	9.6	2.0	16.7	17.0	17.3	15.7
Shortness of Breath	4.9	8.0	0.0	3.9	19.7	23.0	17.3	15.7
Nose Irritation	3.4	3.0	7.7	0.0	7.9	8.0	3.8	0.0
Runny Nose	7.9	8.0	7.7	7.8	31.0	33.0	28.8	29.4
Chest Pain	4.4	7.0	1.9	2.0	10.8	12.0	9.6	9.8
Cough	5.9	11.0	0.0	2.0	24.1	30.0	15.4	21.6

Table 7

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY OR OCCASIONALLY BY AREA RURAL SUBAREAS ONLY

ANDERSON, 1970

	MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	91	48	24	19	112	52	28	32
Nervousness	37.4	41.7	41.7	21.0	66.1	67.3	64.2	65.6
Headache	36.3	41.6	33.3	26.3	45.5	51.9	46.4	34.4
Insomnia	15.4	10.4	20.8	21.0	25.9	25.0	21.4	31.3
Fatigue	29.7	37.4	25.0	15.8	48.2	50.0	42.9	50.0
Palpitations	7.7	6.2	8.4	10.5	13.4	15.3	7.1	15.6
Dizziness	8.8	8.3	8.4	10.5	25.9	21.2	17.9	40.6
Nausea	7.7	12.5	4.2	0.0	13.4	11.6	14.3	15.6
Vomiting	2.2	4.2	0.0	0.0	4.5	0.0	7.1	9.4
Sweating	12.1	16.7	8.4	5.3	24.1	28.9	17.8	21.8
Sinus Congestion	34.1	39.6	16.6	42.1	38.4	38.5	32.2	43.8
Eye Irritation	13.2	16.6	12.5	5.3	19.6	17.3	21.4	21.9
Shortness of Breath	12.1	18.7	8.3	0.0	25.9	26.9	25.0	25.0
Nose Irritation	5.5	8.4	4.2	0.0	9.8	7.7	21.4	3.1
Runny Nose	28.6	33.3	25.0	21.0	33.0	32.7	32.1	34.3
Chest Pain	11.0	14.6	8.4	5.3	10.7	9.6	10.7	12.5
Cough	27.5	39.6	12.5	15.8	21.4	21.1	17.9	25.0

Table 8

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY AND OCCASIONALLY AND DURING THE LAST TWO WEEKS RURAL SUBAREAS ONLY

ANDERSON, 1970

	MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	91	48	24	19	112	52	28	32
Nervousness	20.9	22.9	20.8	15.8	50.0	50.0	46.4	53.1
Headache	22.0	27.1	20.8	10.5	38.4	44.2	39.3	28.1
Insomnia	8.8	6.2	8.3	15.8	22.3	23.1	14.3	28.1
Fatigue	22.0	27.1	20.8	10.5	33.0	42.3	17.9	31.2
Palpitations	2.2	0.0	4.2	5.3	7.1	7.7	7.1	6.2
Dizziness	3.3	4.2	0.0	5.3	16.1	13.5	17.9	18.8
Nausea	2.2	2.1	4.2	0.0	8.9	7.7	7.1	12.5
Vomiting	1.1	2.1	0.0	0.0	1.8	0.0	3.6	3.1
Sweating	4.4	6.3	4.2	0.0	19.6	21.2	14.3	21.9
Sinus Congestion	19.8	25.0	8.3	21.0	23.2	28.8	14.3	21.9
Eye Irritation	7.7	6.2	12.5	5.3	10.7	11.5	14.3	6.2
Shortness of Breath	5.5	10.4	0.0	0.0	14.3	17.3	10.7	12.5
Nose Irritation	2.2	4.2	0.0	0.0	5.4	3.8	14.3	0.0
Runny Nose	16.5	20.8	12.5	10.5	22.3	26.9	14.3	21.9
Chest Pain	9.9	12.5	8.3	5.3	7.1	9.6	3.6	6.2
Cough	18.7	29.2	4.2	10.5	16.1	21.2	7.1	15.6

Table 9

PERCENT DISTRIBUTION OF RESPONDENTS BY SMOKING CATEGORY WITHIN EACH AREA

ANDERSON, 1970

	Area I	Area II	Area III
Total	100.0	100.0	100.0
Never Smoked	36.0	38.1	39.5
Ex Smoker	17.0	21.8	19.1
Present Smoker	47.0	40.1	41.4
Male	100.0	100.0	100.0
Never Smoked	22.9	20.9	21.0
Ex Smoker	25.0	35.8	33.9
Present Smoker	52.1	43.3	45.2
Female	100.0	100.0	100.0
Never Smoked	48.1	52.5	52.2
Ex Smoker	9.6	10.0	8.9
Present Smoker	42.3	37.5	38.9

Table 10

PERCENT OF RESPONDENTS REPORTING COUGH, PHLEGM, SHORTNESS OF BREATH, AND RECENT ILLNESS RURAL SUBAREAS ONLY

ANDERSON, 1970

	MALES				FEMALES			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	91	48	24	19	112	52	28	32
Cough Grade 1 or 2	15.4	22.9	4.2	10.5	10.7	15.4	7.1	6.2
Cough Grade 2	5.5	10.4	0.0	0.0	4.5	9.6	0.0	0.0
Phlegm Grade 1 or 2	18.7	25.0	16.7	5.3	14.3	17.3	17.8	6.2
Phlegm Grade 2	11.0	16.7	8.3	0.0	8.9	9.6	10.7	6.2
Persistent Cough and Phlegm	9.9	16.7	4.2	0.0	6.2	9.6	3.6	3.1
Shortness of Breath Grade 2 or Greater	24.2	29.2	20.8	15.8	40.2	38.5	42.9	40.6
Shortness of Breath Grade 3 or Greater	5.5	6.2	8.3	0.0	7.1	9.6	0.0	9.4

Table 11

PERCENT MEASURABLE ODOR DETECTIONS (ODOR FREQUENCY)

ANDERSON, 1976

TIME	AREA I	AREA II	AREA III	ALL AREAS
1300 1329	50.0	22.2	0.0	21.7
1330 1359	41.7	50.0	20.8	33.3
1400 1429	37.5	22.2	25.0	26.0
1430 1459	58.3	22.2	12.5	28.3
1500 1529	75.0	11.1	0.0	18.8
1530 1559	75.0	11.1	0.0	16.0
1600 1629	41.7	5.6	6.3	15.2
1630 1659	58.3	50.0	0.0	27.1
1700 1729	12.5	0.0	4.2	4.5
1730 1759	75.0	5.6	0.0	21.7
1800 1829	58.3	0.0	8.3	18.8
1830 1859	87.5	0.0	12.5	20.0
1900 1929	58.3	44.4	37.5	45.7
1930 1959	75.0	0.0	12.5	25.0
2000 2029	50.0	38.9	25.0	34.0
2030 2059	83.3	22.2	6.3	30.7
2100 2129	58.3	0.0	4.2	16.7
2130 2159	62.5	0.0	0.0	11.4
Overall	59.4	17.0	9.6	23.2

$$\text{Overall frequency} = \frac{\text{Total number of malodor detections}}{\text{Total number of measurements}} \times 100$$

Table 12

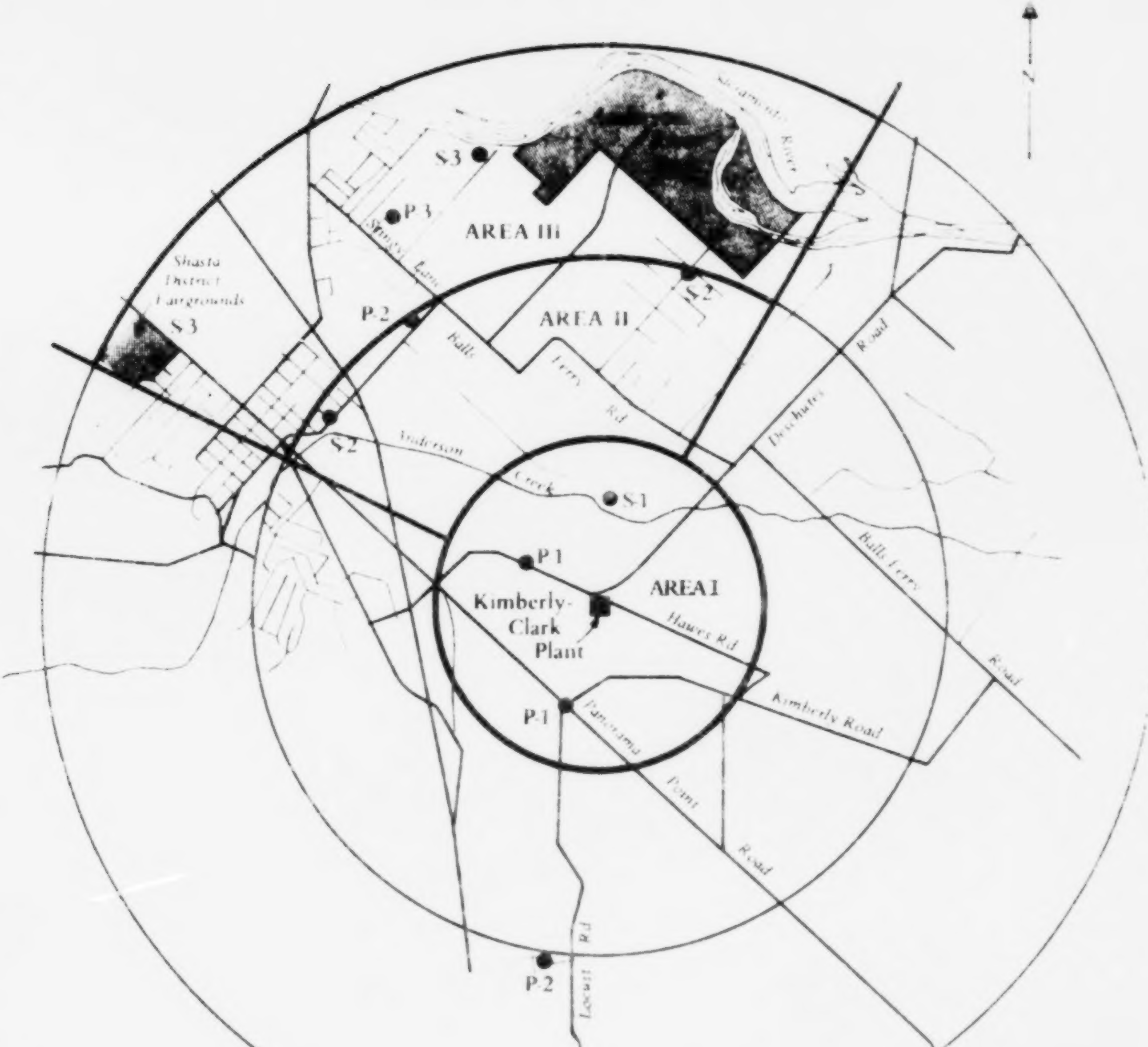
MAXIMUM ODOR CONCENTRATION DETECTED BY AREA AND TIME

(As ppb CH_3SH)

ANDERSON, 1970

TIME	AREA I	AREA II	AREA III
1300-1329	58.0	7.2	N.D.
1330-1359	14.8	5.8	34.4
1400-1429	39.5	15.6	15.5
1430-1459	55.0	8.0	4.2
1500-1529	49.0	N.D.	N.D.
1530-1559	266.2	81.0	N.D.
1600-1629	46.6	13.6	2.7
1630-1659	72.4	8.2	N.D.
1700-1729	17.6	N.D.	6.5
1730-1759	19.0	2.8	N.D.
1800-1829	216.8	N.D.	3.2
1830-1859	384.5	N.D.	3.7
1900-1929	19.1	5.9	75.7
1930-1959	1,681.4	N.D.	22.6
2000-2029	33.7	19.4	6.0
2030-2059	67.6	4.9	6.6
2100-2129	43.8	N.D.	27.2
2130-2159	16.6	N.D.	N.D.

Figure 1


N
Sacramento River
S3
P-3
Stanyel Lane
AREA III
Shasta District Fairgrounds
S3
P-2
P-2
AREA II
Balls Ferry Rd
Deschutes Road
S2
Anderson Creek
S-1
P-1
AREA I
Kimberly-Clark Plant
Hawes Rd
Balls Ferry Road
P-1
Panorama Point Road
Kimberly Road
P-2
Locust Rd

● Indicates sampling sites
for dynamic olfactory

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SECTION VI-E

A COMPARISON OF POSTAL QUESTIONNAIRES AND PERSONAL INTERVIEWS IN ESTIMATING THE FREQUENCIES WITH WHICH SYMPTOMS ARE REPORTED IN RESIDENTIAL AREAS EXPOSED TO PULP MILL ODORS

INTRODUCTION

During August of 1970 the California Air and Industrial Hygiene Laboratory carried out an environmental survey designed to measure the presence and intensity of pulp mill odor in the Anderson-Cottonwood area of northern California.[1] In spite of several limitations (discussed below) this geographic location seemed appropriate for carrying out a health survey in relation to exposure to pulp mill odor. A previous study in a northern coastal area of California (Eureka) had been conducted during the summer of 1969 to estimate annoyance reactions to pulp mill odor and to test their relationship to several measurements of exposure to odor.[2] However, in the Eureka study the health questions were asked only of respondents who indicated that they were "very much" or "moderately" bothered by the odor and referred only to symptoms which the respondent attributed to the odor.

The Anderson study was designed as a health survey of a sample of the population exposed to varying degrees of odor, without regard to whether the respondents reported being bothered by the odor or attributed their symptoms to it. The results of the survey using personal interview have been reported in detail elsewhere.[3] The present paper deals with a comparison of a portion of these results with the results of a postal questionnaire designed to be as nearly as possible comparable to the interview.

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STUDY AIMS

The specific aim of this study is to determine whether the results from personal interview and postal questionnaire lead to similar conclusions concerning the possible health effects of community exposure to pulp mill odor. Implicit in the design of such a study is the selection of comparable population samples and the control of extraneous variables which might affect comparability. The significance of the results is to explore the possibility of replacing the costly, sometimes cumbersome personal interview with the less expensive postal survey.

METHODOLOGY AND MATERIALS

Description of Study Area

According to an estimate made in 1967, the incorporated city of Anderson has a population of 6,137 persons. The town is located at the extreme north of the Sacramento Valley and is exposed to seasonal extremes of temperature and rainfall. The wind pattern is consistent throughout the year, being characterized by winds from the northeast in the morning, shifting to the southeast in the afternoon. The sampling frame for the original personal interview study was comprised of 1,246 households, which included most of the incorporated area as well as some unincorporated districts.

As mentioned above, several limitations of the area were recognized with respect to population surveys. These included the relatively small size of the community, the small proportion of the population which lives near the pulp mill, and the predominantly rural character and modest housing of the area closest to the mill compared with the areas with less exposure to the pulp mill odors.

Selection of Exposure Areas

Before the environmental survey, three areas of Anderson had been defined as representing three levels of presumptive exposure to odor on the basis of topography, prevailing winds, and distance from the mill (Figure 1). The exposure was subsequently confirmed by the measurements made by dynamic olfactometry. Although these measurements were made in August and the health survey was carried out the following November, the seasonal factor was felt to be unimportant because the prevailing wind pattern is essentially the same all year round. Because of the diurnal wind pattern, measurements south of the mill were made in the morning, and measurements north of the mill were made in the afternoon.

As a result of the environmental survey, the area farthest from the mill was selected to represent slight exposure to the odor, the area closest to the mill was used to represent the greatest exposure to the odor, and the area between represented moderate exposure.

Exposure Measurements

The exposure to odor in the three areas was estimated by dynamic olfactometry. The measurements are based on the "odor dilution factor", which is the ratio of ambient air (air to which the community is exposed) to odorless air at which a trained observer just detects malodor. This is converted to the equivalent of parts per billion of a specific odorant by multiplying by the odor threshold of each observer, which is the ratio of a known dilution of a specific odorant to odorless air at which the observer just detects the odor.

The sensitivity of the method is a function of the observer's odor threshold and the lowest dilution of odorant to odorless air that can be measured on the olfactometer. In order to sample the ambient air adequately, daily observations were obtained during the period from August 24 through September 4, 1970, excluding the weekend of August 29-30. Two observers were exposed to the ambient air at several sites in each of the three areas at half-hour intervals during each day. The sampling sites, the method of sampling the ambient air, and the instrumentation and technique of using the olfactometer are described in detail elsewhere.[1,4,5] The odor threshold of each observer was measured twice a day.

Population Sampling

Preliminary scouting of the original three "exposure" areas suggested that significant differences occurred in housing and type of neighborhood, including population density. These differences implied possible differences in level of income and other social factors affecting health. It was not feasible to characterize subareas with any degree of precision, but some stratification seemed advisable. Consequently, each "exposure" area was subdivided into three subareas, one characterized predominantly by scattered rural housing, one by central town-type housing, and one by suburban tract-type housing. The rural housing was defined primarily on the basis of sparsity of settlement, but appeared to represent a relatively large proportion of housing of poor quality, frequently located on property which included farm outbuildings and livestock. The suburban tract-type housing was on the outskirts of town and was largely "California ranch" style. The housing in the central areas tended to be more modest and was located in the older, central part of town with a conventional grid pattern of streets. The "exposure" areas will subsequently be referred to as Areas I, II, and III, representing high, moderate, and low exposure to pulp mill odor, and the subareas will be designated as rural, central and tract.

The sampling frame was constructed for each subarea by listing all houses which appeared to be occupied. For the personal interview survey, houses unoccupied at the time of interview were replaced by sampling randomly between the "interviewed" houses on either side. For both the interview and postal survey, sampling was systematic with an independent random start in each subarea. Alternate households were designated to have a male or female respondent interviewed. If a household did not have a respondent of the designated sex, one of the other adult members was substituted.

The personal interview survey was regarded as the main part of the survey with respect to investigating the health effects of exposure to pulp mill odor. Therefore, this sample was selected first, and the sample sizes were chosen so as to permit some comparisons within residential subgroups as well as between totals for each of the three areas. The sample for the postal survey was chosen from the same initial sampling frame, excluding households included in the personal interview sample. The sampling frame was not large enough to permit carrying out the postal survey in Area I, the area nearest the pulp mill, nor in the rural subarea of Area II. In this report comparisons are made only between combinations of comparable subareas. Thus, no comparisons are possible for Area I, and comparisons are limited to central and tract subareas for Area II, but are made for rural, central, and tract subareas combined for Area III. The lack of postal survey data for Area I is a serious limitation of the study since this area represents the greatest exposure to the odor. Also, the high sampling ratios in some subareas may have been a disadvantage because of the possibility of bias resulting from pre-interview discussion of the survey among prospective respondents.

The total sample sizes, numbers of respondents, and numbers of non-respondents by category are shown for both the personal interview and the postal survey (Table 1).

Questionnaire Design

For both the personal interview and the postal survey, the questionnaire included information regarding date of birth, sex, marital status, occupation and place of employment, length of residence in the area, pre-existing medical conditions, smoking habits, and exposure to specific industrial hazards which might affect health. The basic questions of the British Medical Research Council's Questionnaire on Respiratory Symptoms (1966)[6] were included as a measure of chronic respiratory effects. This was followed by [illegible] sets of questions concerning symptoms which it was believed might be associated with exposure to pulp mill odor. The respondent was first asked whether he had each of these symptoms frequently, occasionally, or hardly ever. For each symptom experienced frequently or occasionally, he was then asked whether there was anything in particular which seems to bring it on, or whether he had experienced it during the past two weeks. He was also asked whether he had been sick at any time during the last two weeks, and whether he would say that his health was excellent, good, fair, or poor. It proved to be cumbersome and time-consuming in the personal interview to ask this much detail for each symptom, but no estimate existed of the frequency of these symptoms in the general population, and we hoped to obtain adequate frequencies of positive responses to at least one set of questions to permit statistical testing of the results. It was also felt that the respondent should be given an opportunity to attribute symptoms to the pulp mill odor although both the interview and the postal questionnaire were introduced to the respondent as general health surveys and no references were made to pulp mill odor anywhere in either questionnaire. This has been found to be important in obtaining unbiased results.[7]

Interviewing was carried out by two part-time and four full-time interviewers, including two staff members who participated in other aspects of the survey. Training began on the Wednesday evening preceding the field work and continued through part of the following Saturday. A preliminary description of the study and run-through of the questionnaire and instructions was followed by demonstration interviews by staff members and practice interviews by staff members and trainees. Standard training tape recordings of demonstration interviews of the MRC part of the questionnaire were also used. The most intensive part of the training consisted of one-to-one interviewing practice with members of the training staff, followed by playback of tape recordings and group discussion. The final phase of training included "real" interviews on members of a community not being included in the survey proper. Completed questionnaires were edited by staff members and discussed with the trainees.

The initial plan required each interviewer to interview the same proportion of respondents in each area, and to do about the same proportion of interviews on each day in each area. The former should have equalized interviewer differences so that they would not appear as area differences; the latter was to insure that increasing community awareness and discussion of the content of the study would occur at the same rate in all areas. In practice, it became increasingly difficult to maintain this schedule beyond the first few days of interviewing.

Each interviewer was usually seen by a staff member at least once a day for collection of completed interview schedules, assignment of new interviews, and discussion of problems. Preliminary editing of interview schedules was done on a current basis so that omissions or errors could be corrected while field work was still in progress.

Postal Survey

From the total listing of all residences which comprised the original sampling frame, a sample of 245 addresses was selected for the postal survey, as previously described. No addresses were included which had already been included in the personal interview survey. In order to avoid addressing mail to "occupant", it was necessary to obtain names of householders, and this proved to be one of the most difficult aspects of the survey. No telephone directory by street address existed for the area, nor was a postal guide by street address available. Furthermore, postal service included both delivery by street address and by rural route and box number. In addition, some residents receive their mail through post office boxes. The local municipal water department cooperated in providing names of persons receiving water bills for 146 of the original 245 addresses, but these did not necessarily represent occupants. The Anderson Post Office, through the excellent cooperation of the Postmaster and the deliverymen, was able to provide names for 115 of the original 245 addresses. The two lists were checked against each other to eliminate duplicates and subsequently combined into a single list. As additional verification, these were checked against the local telephone directory.

The result was a list of 202 names matched to addresses, leaving 43 unmatched addresses.

The postal questionnaire was mailed to the 202 prospective respondents on April 12, with a follow-up questionnaire mailed on April 22 to non-respondents. On May 12, a final mailing was made by certified mail to non-respondents. From the series of three mailings, completed questionnaires were received from 70.3 percent of the 202 prospective respondents. Follow-up consisted of fourth and fifth mailings to the 43 non-respondents and the 43 unknowns, addressed to "occupant" and sent, by necessity, by fourth class mail. Completed questionnaires were received from 40.7 percent of these (Table 2).

In summary, from the 245 addresses originally included in the sample, completed questionnaires were received from 72.2 percent. The remaining 27.8 percent included refusals, vacant households, deceased respondents, and unclaimed mail (mostly representing occupants who had moved).

RESULTS

Several hypotheses comparing the postal and personal interview surveys are of interest. The first concerns differences in response rate and whether there is evidence of any bias. A second hypothesis is whether the frequencies with which various symptoms are reported is the same or whether there is some consistent relationship between frequencies reported by the two methods. A third asks whether the same area differences are detected by both methods.

Comparison of Response Rates

As expected, the response rates for the postal survey are considerably lower than those for personal interview (72.2 compared to 97.2 percent for both areas combined). However, at least some of this difference is due to inclusion in the denominator of unclaimed mail (returned by the post office), and mail delivered to an address but not reaching the respondent or resulting for any reason in "no reply". The percent response for the postal survey based on a denominator excluding vacant houses, unclaimed mail and deceased occupants is 82.3 percent, while the additional exclusion from the denominator of "no replys" (but not explicit refusals) results in a response rate of 97.8 percent. In any case, the response rates for both areas are close.

Comparisons of Prevalence Reported by Personal Interview and Postal Questionnaire

Frequency with which Symptoms are Reported

Since the distributions of respondents by sex and area (cross-classified) were very nearly the same for both personal interview and postal questionnaire (Table 3), the comparison of results obtained by each method was made for both sexes and areas combined. For the percent reporting symptoms *frequently*, no statistically significant differences between the two methods were found using χ^2 tests. For the percent reporting symptoms frequently or occasionally, the following symptoms showed significant differences between the two methods: nervousness, headache, fatigue, sweating, sinus congestion, nose irritation, runny nose, and chest pain. All of these symptoms showed a larger percent reporting by postal questionnaire than upon personal interview (Table 4). Most differences which were not statistically significant also occurred in this direction. When examined separately by sex, however, only nervousness and headache showed significant differences within both sexes. Percents reporting runny nose and chest pain, although significantly different for both sexes combined, were not significant within either sex when considered separately. Conversely, the percent reporting insomnia showed a significant difference in men, and eye irritation showed a significant difference in women, but neither showed significant differences for both sexes combined (Table 5).

MRC Symptoms

χ^2 tests were also carried out on the percents reporting individual MRC symptoms to compare the postal and interview surveys (Table 6). The questions on phlegm all received a significantly larger percent of positive responses on the postal questionnaire than on personal interview, as did the question asking whether the respondents chest sounds wheezing and whistling on most days or nights. It should be noted, however, that the questions on phlegm yielded the lowest response rate, apparently due to ambiguity of the questionnaire format. The results, therefore, are based on only about 85 percent of the total sample.

Percents giving positive responses to the MRC questions are also shown by sex and area (Table 7).

Area Differences

Frequency with which Symptoms are Reported

One hypothesis of interest is whether area differences detected by the postal survey consistently reflect those detected by personal interview. To test this the signs of the area differences in percents reporting symptoms (Area II minus Area III) were determined separately by sex for personal interview and for postal questionnaire (Tables 8 and 9). Concordance was defined as agreement between the signs of the area differences for postal and interview results for a given sex and symptom; discordance was defined as disagreement between the signs. When no area difference occurred for either postal survey or interview, the pair was omitted.

The null hypothesis implies that 50 percent of the differences are concordant and 50 percent are discordant, which is the expected distribution if no consistency is occurring in the direction of area differences when all symptoms are considered together.

For percent of males reporting symptoms frequently, 8 out of 11 symptoms showed concordance in the sign of the area differences, 3 out of 11 showed discordance (5 symptoms showed no difference between areas for either the postal survey or the personal interview or both); comparable results for females were 8 out of 16 symptoms showing concordance and 8 out of 16 symptoms showing discordance. Comparable figures for percents reporting symptoms frequently or occasionally are 6 out of 10 symptoms showing concordance and 4 out of 10 symptoms showing discordance for males, and 9 out of 16 showing concordance and 7 out of 16 showing discordance for females. The only comparison approaching statistical significance was the 8 out of 11 agreement for males reporting symptoms frequently. For a one-tailed test of statistical significance at the 5 percent level, agreement for 9 out of 11 symptoms would have been required. This would have been achieved by counting as "agreement" the symptom in which both postal and personal interview results showed no area difference.

A more appropriate test might be considered to be a similar one done only on those symptoms which showed statistically significant area differences. However, only one such difference occurred. This was for the percent reporting "runny nose" frequently on the postal questionnaire ($\chi^2 = 8.45$ with one degree of freedom).

Implicit in the hypothesis tested here is that if the postal and interview methods are to be accepted as equally valuable in detecting area differences, a statistically significant proportion of the symptoms must show area differences consistent in direction by both methods. It could be argued that if postal and interview results give similar area differences on some symptoms and not on others, then it is valid to use results from either method for these symptoms, but that the other symptoms are not suitable for survey use unless one is willing to accept either the interview or the postal methods as the "reference" method. For example, if from other evidence one decides that the interview method is valid (perhaps based on comparisons with other medical data on the respondents), then obtaining an area difference on the postal survey which differs in direction from the area difference obtained by interview suggests that the postal survey is not an adequate replacement for interview. Again, one may wish to limit the comparisons to statistically significant differences which are also large enough to be relevant to the goals of the study.

MRC Symptoms

Area differences in the prevalence of MRC symptoms were also compared for postal survey and personal interview (Table 10). Neither type of survey gave significant area differences for any of the MRC symptoms examined. The non-significant area differences showed the same direction for both surveys for some symptoms, but not for others.

Environmental Measurements

Three indices of odor as measured by dynamic olfactometry are presented. These are the percent measurable detections, the concentration at the 90th percentile, and the maximum odor concentration detected (Tables 11-13). Area I, which could not be used in the comparisons presented here, obviously has a greater exposure to odor than the other areas. The distinction between Areas II and III are less obvious, and the limitation of the postal-interview comparison to these areas represents a deficiency in the study when making area comparisons.

SUMMARY AND DISCUSSION

The lower response rate to the postal questionnaire when compared with personal interview is to be expected for two reasons; first, the initial sample was selected by address and corresponding names were obtained from several sources which were not necessarily accurate, and questionnaires to the remaining addresses had to be sent to "occupant" by fourth class mail; second, non-response may be accomplished merely by ignoring the mailed questionnaire in contrast to explicit face-to-face refusal in the case of the personal interview. Considering the difficulties encountered in obtaining names of householders in the sample, the response rate appears to be reasonably satisfactory. In terms of area differences in reported frequency of symptoms, the occurrence of similar response rates in both areas suggests lack of bias in this respect.

In comparing results of the postal survey and personal interview, the higher percents of positive responses in the postal questionnaire could result partly from the under-representation of individuals reluctant to respond because they had few or no symptoms. These individuals would ordinarily be picked up in personal interview. It has been found in other studies that a higher frequency of reporting of "personal" information may be obtained by postal survey than on personal interview. The symptoms showing higher frequencies in the postal survey were nervousness, headache, fatigue, sweating, sinus congestion, nose irritation, runny nose, and chest pain; and of the MRC symptoms, phlegm and chest sounding wheezing or whistling.

The attempt to test whether the same area differences in symptom frequencies would be detected by both postal survey and personal interview was unsuccessful because no significant area differences occurred by either method. This may be a reflection of the relatively small difference between the two areas with respect to exposure to odor. It was unfortunate that Area I, which had significantly greater exposure to odor than Areas II and III, was too small to be included in the postal survey.

Table 1

SUMMARY OF RESPONSES
POSTAL SURVEY AND PERSONAL INTERVIEW
ANDERSON, 1970–1971

	PERSONAL INTERVIEW		
	Total	Area II	Area III
Total Initial Sample	254	102	152
Respondents	247	95	152
Percent	97.2	93.1	100.0
Refusals	6	6	0
Vacant House	1	1	0
	POSTAL SURVEY		
	Total	Area II	Area III
Total Initial Sample	245	93	152
Respondents	177	67	110
Percent	72.2	72.0	72.4
Refusals (returned questionnaire but refused to answer)	4	1	3
No Reply (mail undelivered or refused)	34	17	17
Deceased	1	1	0
Mail Unclaimed (returned by post office)	24	6	18
Vacant House	5	1	4

Table 2

SUMMARY OF MAILINGS AND RESPONSES
POSTAL SURVEY
ANDERSON, 1971

	TOTAL			AREA II			AREA III		
	Mailed	Questionnaires Returned		Mailed	Questionnaires Returned		Mailed	Questionnaires Returned	
	Number	Number	Percent	Number	Number	Percent	Number	Number	Percent
First Mailing April 12 (First Class)	202	74	36.6	83	30	36.1	119	[illegible]	[illegible]
Second Mailing April 22 (First Class)	113	38	33.6	52	15	[illegible]	[illegible]	[illegible]	[illegible]
Third Mailing May 12 (Certified)	84	30	35.7	37	13	35.1	47	[illegible]	[illegible]
Fourth Mailing May 28 (Fourth Class)	86	25	29.1	32[a]	[illegible]	15.6	54[b]	[illegible]	[illegible]
Fifth Mailing June 18 (Fourth Class)	46	10	21.7	21	3	14.3	25		28.0

[a] Includes 10 questionnaires not sent first three mailings because of lack of name for the given address.

[b] Includes 33 questionnaires not sent per footnote a.

Table 3

PERCENT OF RESPONDENTS BY SEX AND AREA
POSTAL SURVEY AND PERSONAL INTERVIEW
ANDERSON, 1970 1971

	POSTAL SURVEY	PERSONAL INTERVIEW
Number of Respondents	177	247
Percents	100.0	100.0
Male, total	37.8	42.5
Area II	14.1	17.4
Area III	23.7	25.1
Female, total	62.2	57.5
Area II	27.7	21.1
Area III	34.5	36.4

Table 1

COMPARISON OF POSTAL SURVEY AND PERSONAL INTERVIEW PERCENT OF RESPONDENTS REPORTING SYMPTOMS "FREQUENTLY" OR "FREQUENTLY AND OCCASIONALLY" ANDERSON, 1970 - 1971

SYMPTOM	FREQUENTLY			FREQUENTLY OR OCCASIONALLY		
	χ^2	Postal	Interview	χ^2	Postal	Interview
Number of Respondents		167ᵃ	247		167ᵃ	247
Nervousness	2.85	19.8	27.5	11.33**	64.7	[illegible]
Headache	1.43	10.8	15.4	10.52**	50.6	[illegible]
Insomnia	2.41	6.0	10.9	1.31	31.1	[illegible]
Fatigue	0.02	15.0	15.6	10.01**	53.9	[illegible]
Palpitations	0.00	2.4	2.8	0.25	12.0	[illegible]
Dizziness	0.04	2.4	3.2	0.01	17.4	16.2
Nausea	0.01	1.8	2.4	[illegible]	[illegible]	[illegible]
Vomiting	0.20	0.6	0.4	0.69	8.1	3.2
Sweating	0.00	9.0	9.3	14.16**	[illegible]	17.0
Sinus Congestion	[illegible]	[illegible]	13.8	5.80*	[illegible]	[illegible]
Eye Irritation	0.00	3.6	4.0	2.61	24.0	17.0
Shortness of Breath	0.01	7.2	6.9	0.57	[illegible]	18.6
Nose Irritation	2.59	4.2	1.2	12.46**	15.6	[illegible]
Runny Nose	0.00	6.6	6.1	4.55*	33.5	23.5
Chest Pain	0.06	1.1	3.2	5.27*	18.0	9.7
Cough	1.38	7.2	4.0	1.80	28.1	[illegible]

ᵃ Excludes 10 questionnaires returned in which these questions were not answered.

* Significant at 5% level.
** Significant at 1% level.

Note: χ^2 with one degree of freedom comparing postal survey and personal interview.

Table 5

PERCENT OF RESPONDENTS REPORTING SYMPTOMS "FREQUENTLY OR OCCASIONALLY" BY SEX POSTAL SURVEY AND PERSONAL INTERVIEW ANDERSON, 1970–1971

	MALE			FEMALE		
	χ^2	Postal	Interview	χ^2	Postal	Interview
Number of Respondents		69[a]	105		98[a]	142
Nervousness	5.24*	47.8	29.5	5.99*	76.5	60.6
Headache	4.16*	40.6	24.8	5.76*	58.2	41.5
Insomnia	4.87*	30.4	15.2	0.01	31.6	33.1
Fatique	6.35*	42.0	22.9	3.82	62.2	48.6
Palpitations	0.06	8.7	8.6	0.42	14.3	18.3
Dizziness	0.11	8.7	11.4	0.01	23.5	23.2
Nausea	0.23	4.3	1.9	2.45	19.4	11.3
Vomiting	0.04	0.0	1.0	1.07	9.2	4.9
Sweating	11.52**	39.1	15.2	3.56	29.6	18.3
Sinus Congestion	0.38	39.1	33.3	6.07*	52.0	35.2
Eye Irritation	0.01	14.5	15.2	4.24*	30.6	18.3
Shortness of Breath	0.08	11.6	14.3	1.08	28.6	21.8
Nose Irritation	1.04	8.7	3.8	10.89**	20.4	5.6
Runny Nose	0.94	27.5	20.0	3.19	37.8	26.1
Chest Pain	0.38	11.6	7.6	0.21	22.4	11.3
Cough	0.01	24.6	22.9	2.30	30.6	21.1

[a] Excludes 10 questionnaires returned in which these questions were not answered.

* Significant at the 5% level.
** Significant at the 1% level.

Note: χ^2 with one degree of freedom comparing postal survey and personal interview.

Table 6

PERCENT OF RESPONDENTS REPORTING MRC SYMPTOMS POSTAL SURVEY AND PERSONAL INTERVIEW

(Based on number answering each question)

ANDERSON, 1970 - 1971

SYMPTOM	χ^2	POSTAL	INTERVIEW
Number of Respondents		150 177	247
Morning Cough	2.20	15.4	10.1
Day or Night Cough	0.38	13.1	15.8
Cough Most Days Last Three Months	0.31	11.4	13.8
Cough Grade 1 or 2	0.24	11.6	13.8
Cough Grade 2	0.88	7.6	4.9
Morning Phlegm	6.15*	17.3	8.5
Day or Night Phlegm	6.95**	19.5	9.7
Phlegm Most Days Last Three Months	8.48*	19.5	9.7
Period of Increased Cough and Phlegm Lasting Three Weeks or More			
Once during last three years	0.80	4.3	6.9
Twice during last three years	2.30	9.1	4.9
Shortness of Breath			
Walking at an ordinary pace	0.85	29.2	34.0
Walking at own pace	0.19	11.1	9.3
Breath Wheezing or Whistling Most Days	4.88*	11.1	4.9
Attacks of Shortness of Breath or Wheezing - Normal Between	0.53	7.6	10.1
Stuffy Nose Most Days Last Three Months	1.62	22.9	17.4
Chest Illness Past Three Years			
Once only	0.18	3.5	4.9
Twice or more	0.40	4.1	2.4

* Significant at the 5% level.

** Significant at the 1% level.

Note: χ^2 with one degree of freedom comparing postal survey with personal interview.

Table 7

PERCENT OF RESPONDENTS REPORTING MRC SYMPTOMS
BY SEX AND AREA
POSTAL SURVEY VS PERSONAL INTERVIEW

(Based on number answering each question.)

ANDERSON, 1970-1971

SYMPTOM	MALE				FEMALE			
	Postal		Interview		Postal		Interview	
	Area II	Area III	Area II	Area III	Area II	Area III	Area II	Area III
Number of Respondents	18-25	42-49	43	62	37-42	53-61	52	90
Morning Cough	16.0	16.3	11.6	8.1	16.7	13.6	11.5	10.0
Day or Night Cough	4.0	8.5	30.2	14.5	19.0	16.4	11.5	12.2
Cough Most Days Last Three Months	4.2	10.2	25.6	12.9	16.7	11.7	13.5	8.9
Cough Grade 1 or 2	4.2	10.6	25.6	12.9	16.7	11.9	13.5	8.9
Cough Grade 2	4.2	6.4	9.3	4.8	11.9	6.8	3.8	3.3
Morning Phlegm	22.2	16.7	14.0	9.7	16.2	17.0	3.8	7.8
Day or Night Phlegm	21.1	21.4	16.3	14.5	20.5	16.7	1.9	7.8
Phlegm Most Days Last Three Months	21.1	18.6	18.6	9.7	23.7	16.7	1.9	7.8
Period of Increased Cough and Phlegm Lasting Three Weeks or More								
Once during last three years	4.2	4.3	4.7	4.8	2.9	5.1	15.4	4.4
Twice during last three years	8.3	2.2	4.7	8.1	20.0	8.5	1.9	4.4
Shortness of Breath								
Walking at an ordinary pace	28.0	18.8	27.9	22.6	40.5	31.1	40.4	41.1
Walking at own pace	0.0	2.1	18.6	6.5	21.6	16.4	5.8	8.9
Breath Wheezing or Whistling Most Days	16.0	10.4	7.0	4.8	12.8	13.6	1.9	5.6
Attacks of Shortness of Breath or Wheezing—Normal Between	0.0	2.1	14.0	9.7	10.0	13.3	0.0	4.4
Stuffy Nose Most Days Last Three Months	12.5	14.9	20.9	25.6	35.0	24.6	21.2	23.1
Chest Illness Past Three Years								
Once only	0.0	2.1	7.0	3.2	7.7	3.3	3.8	5.6
Twice or more	4.2	0.0	0.0	7.1	7.7	5.0	1.9	3.3

Table 8

PERCENT OF RESPONDENTS REPORTING SYMPTOMS "FREQUENTLY OR OCCASIONALLY" BY AREA AND SEX BY POSTAL SURVEY AND PERSONAL INTERVIEW ANDERSON 1970–1971

SYMPTOM	MALE				FEMALE			
	Postal		Interview		Postal		Interview	
	Area II	Area III	Area II	Area III	Area II	Area III	Area II	Area III
Number of Respondents	23[a]	46[a]	43	62	40[a]	58[a]	52	90
Nervousness	47.8	47.8	39.5	22.6	75.0	77.6	63.5	58.9
Headache	47.8	37.0	27.9	22.6	52.5	62.1	51.9	38.9
Insomnia	30.4	30.4	18.6	12.9	37.5	34.5	32.7	32.2
Fatigue	47.8	39.1	20.9	24.2	62.5	62.1	48.1	46.7
Palpitations	8.7	8.7	11.6	6.5	20.0	10.3	11.5	12.2
Dizziness	13.0	6.5	11.6	11.3	27.5	20.7	19.2	25.6
Nausea	13.0	0.0	9.3	3.2	20.0	15.5	13.5	10.0
Vomiting	0.0	0.0	2.3	0.0	12.5	6.9	3.8	6.7
Sweating	52.2	32.6	14.0	16.1	37.5	27.6	19.2	7.8
Sinus Congestion	39.1	39.1	32.6	33.9	[illegible]	44.8	36.5	31.1
Eye Irritation	21.7	10.9	18.6	12.9	[illegible]	25.9	19.2	17.8
Shortness of Breath	13.0	10.9	16.3	12.9	32.5	25.9	21.2	12.2
Nose Irritation	8.7	8.7	7.0	1.6	27.5	15.5	7.7	4.4
Runny Nose	39.1	21.7	18.6	21.0	45.0	32.8	32.7	22.2
Chest Pain	8.7	13.0	7.0	8.1	27.5	19.0	13.5	10.0
Cough	30.4	21.7	25.6	21.0	40.0	24.1	23.1	20.0

[a] Excludes a total of 10 questionnaires in which these questions were not answered.

Table 9

AREA DIFFERENCES IN PERCENT OF RESPONDENTS REPORTING SYMPTOMS "FREQUENTLY" AND "FREQUENTLY OR OCCASIONALLY" BY SEX POSTAL SURVEY AND PERSONAL INTERVIEW

(Area II – Area III)
ANDERSON, 1970

	FREQUENTLY				FREQUENTLY OR OCCASIONALLY			
	Male		Female		Male		Female	
	Postal	Interview	Postal	Interview	Postal	Interview	Postal	Interview
Number of Respondents								
Nervousness	-4.4	+1.1	+6.6	-5.4	0	+16.9	2.6	+4.6
Headache	+10.8	+4.5	-3.0	+8.0	+11.8	+5.3	9.6	+16.3
Insomnia	+2.1	+3.8	-5.3	6.3	0	+5.7	7.0	0.6
Fatique	8.7	2.7	5.7	3.8	+8.7	3.3	+0.4	0.8
Palpitations	0	1.6	+1.6	0.6	0	+5.1	+9.7	10.7
Dizziness	0	3.2	-2.7	+2.5	+6.5	+0.3	+6.8	-0.75
Nausea	0	1.6	-5.2	+0.5	+13.0	3.2	+9.5	+3.5
Vomiting	0	0	-1.7	-1.1	0	+2.3	+5.6	4.8
Sweating	+2.1	0.4	+0.6	+0.7	+19.6	2.1	+4.9	+1.4
Sinus Congestion	6.5	0.5	+2.9	+9.2	0	1.3	+17.7	+2.1
Eye Irritation	+13.0	+0.7	-0.9	+0.2	+10.8	+5.7	+11.6	+1.4
Shortness of Breath	0	+4.5	+1.4	+1.0	+2.1	+3.4	+6.6	1.0
Nose Irritation	4.3	+0.7	+4.1	+1.9	0	+5.4	+12.0	+3.3
Runny Nose	+4.4	+1.5	+17.5	+9.1	+17.4	2.4	+12.2	+10.5
Chest Pain	+4.3	+1.5	+2.3	1.4	4.3	1.1	+8.5	+3.5
Cough	4.3	2.5	+8.1	0.6	+8.7	+4.6	+15.9	+3.1

Table 10

PERCENT OF RESPONDENTS REPORTING MRC SYMPTOMS BY AREA POSTAL SURVEY AND PERSONAL INTERVIEW

(Based on number answering each question)

ANDERSON, 1970 - 1971

SYMPTOM	POSTAL SURVEY			PERSONAL INTERVIEW		
	χ^2	Area II	Area III	χ^2	Area II	Area III
Number of Respondents		55/62	95/101		95	182
Morning Cough	0.00	10.3	[illegible]	0.18	11.6	[illegible]
Day or Night Cough	0.02	[illegible]	[illegible]	1.98	20.6	[illegible]
Cough Most Days Last Three Months	0.00	12.1	13.0	2.82	14.0	10.9
Cough Grade 1 or 2	0.00	12.1	[illegible]	0.00	[illegible]	[illegible]
Cough Grade 2	0.03	5.1	6.6	0.23	6.3	[illegible]
Morning Phlegm	0.00	16.7	11.8	0.00	8.4	[illegible]
Day or Night Phlegm	0.01	[illegible]	18.8	0.16	8.1	[illegible]
Phlegm Most Days Last Three Months	[illegible]	[illegible]	17.5	0.00	[illegible]	[illegible]
Period of Increased Cough and Phlegm Lasting Three Weeks or More						
Once during last three years	0.00	3.1	[illegible]	2.43	10.8	[illegible]
Twice during last three years	3.07	[illegible]	[illegible]	0.46	3.7	[illegible]
Shortness of Breath						
Walking with ordinary pace	[illegible]	[illegible]	[illegible]	0.00	[illegible]	11.6
Walking at own pace	0.10	12.9	10.1	0.58	11.6	[illegible]
Breath Wheezing or Whistling Most Days	1.44	15.6	8.4	0.00	4.2	[illegible]
Attacks of Shortness of Breath with Wheezing, Normal Between	0.04	6.2	8.3	0.15	11.6	9.2
Stuffy Nose Most Days Last Three Months	0.56	26.6	20.4	1.04	21.1	[illegible]
Chest Illness With Phlegm Past Three Years						
Once only	0.06	4.8	2.8	0.00	5.3	4.6
Twice or more	0.54	6.3	2.8	0.47	1.1	3.3

Note: χ^2 with one degree of freedom comparing postal survey and personal interview.

Table 11

PERCENT MEASURABLE ODOR DETECTIONS
(ODOR FREQUENCY)
ANDERSON, 1970

TIME	AREA I	AREA II	AREA III
1300-1329	50.0	22.2	0.0
1330-1359	41.7	50.0	20.8
1400-1429	37.5	22.2	25.0
1430-1459	58.3	22.2	12.5
1500-1529	75.0	11.1	0.0
1530-1559	75.0	11.1	0.0
1600-1629	41.7	5.6	6.3
1630-1659	58.3	50.0	0.0
1700-1729	12.5	0.0	4.2
1730-1759	75.0	5.6	0.0
1800-1829	58.3	0.0	8.3
1830-1859	87.5	0.0	12.5
1900-1929	58.3	44.4	37.5
1930-1959	75.0	0.0	12.5
2000-2029	50.0	38.9	25.0
2030-2059	83.3	22.2	6.3
2100-2129	58.3	0.0	4.2
2130-2159	62.5	0.0	0.0
Overall	59.4	17.0	9.6

$$(\text{Overall frequency} = \frac{\text{Total number of malodor detections}}{\text{Total number of measurements}} \times 100)$$

Table 12

DIURNAL MALODOR CONCENTRATION AT 90th PERCENTILE BY AREA AND TIME (as ppb CH_3SH) ANDERSON, 1970

	AREA I	AREA II	AREA III
1300	29.6	6.2	N.D.
1330	11.4	8.3	[illegible]
1400	17.8	4.8	6.2
1430	11.6	5.7	N.D.
1500	15.3	N.D.	N.D.
1530	181.3	N.D.	N.D.
1600	16.1	N.D.	N.D.
1630	11.5	5.3	N.D.
1700	N.D.	N.D.	N.D.
1730	15.0	N.D.	N.D.
1800	58.3	N.D.	N.D.
1830	115.8	N.D.	N.D.
1900	12.6	4.1	55.0
1930	401.3	N.D.	N.D.
2000	17.3	10.1	4.0
2030	14.0	4.4	N.D.
2100	31.6	N.D.	N.D.
2130	11.5	N.D.	N.D.

N.D. None detected.

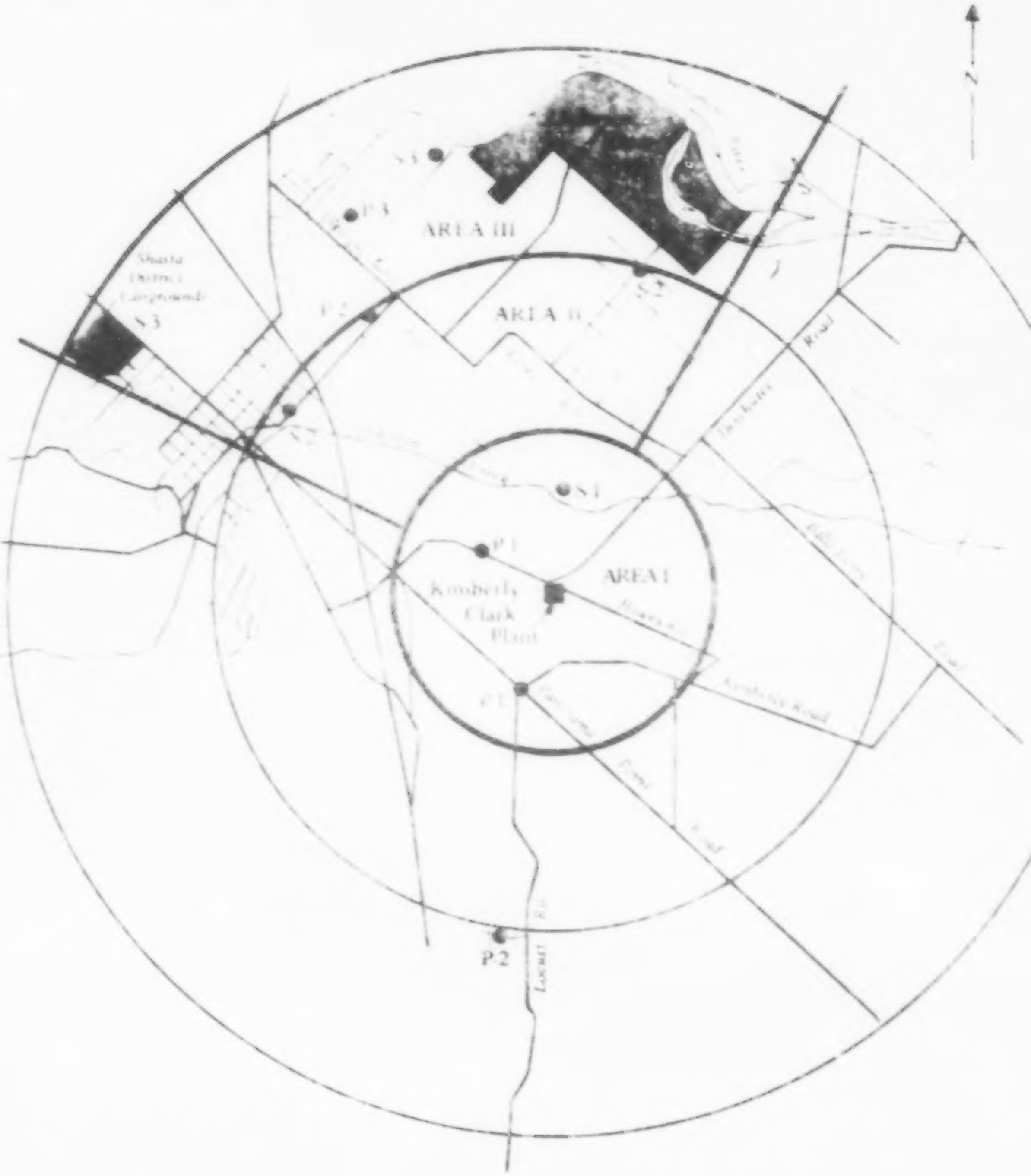
Table 13

MAXIMUM ODOR CONCENTRATION DETECTED BY AREA AND TIME

(AS ppb CH_3SH)
ANDERSON, 1970

TIME	AREA I	AREA II	AREA III	ALL AREAS
1300–1329	58.0	7.2	N.D.	58.0
1330–1359	14.8	5.8	34.4	34.4
1400–1429	39.5	15.6	15.5	39.5
1430–1459	55.0	8.0	4.2	55.0
1500–1529	49.0	N.D.	N.D.	49.0
1530–1559	266.2	81.0	N.D.	266.2
1600–1629	46.6	13.6	2.7	46.6
1630–1659	72.4	8.2	N.D.	72.4
1700–1729	17.6	N.D.	6.5	17.6
1730–1759	19.0	2.8	N.D.	19.0
1800–1829	216.8	N.D.	3.2	216.8
1830–1859	384.5	N.D.	3.7	384.5
1900–1929	19.1	5.9	75.7	75.7
1930–1959	1,681.4	N.D.	22.6	1,681.4
2000–2029	33.7	19.4	6.0	33.7
2030–2059	67.6	4.9	6.6	67.6
2100–2129	43.8	N.D.	27.2	43.8
2130–2159	16.6	N.D.	N.D.	16.6

Figure 1


N
S3
P3
AREA III
Shasta
District
Fairgrounds
S3
P2
S2
AREA II
S2
Deschutes
Road
S1
P1
AREA I
Kimberly
Clark
Plant
Airport Road
Road
Road
P2
Locust Rd

● Indicates sampling sites
for dynamic olfactory

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SECTION VI-F

ANNOYANCE AND HEALTH REACTIONS TO ODOR FROM REFINERIES AND OTHER INDUSTRIES IN CARSON, CALIFORNIA

1972

INTRODUCTION

Several studies previously conducted in California and elsewhere on the effects of odor from industrial sources have demonstrated that annoyance reactions, as measured by personal interviews, are related both to presumptive exposure to odor, as estimated from location, and to systematic measurements of exposure made by dynamic olfactometry.[1-6] The sources of odors in the California studies were pulp and paper mills situated close to residential communities and, therefore, represented one or two point sources in each community.[4,5] This paper is a report of the effects of community exposure to multiple sources of odor associated with petroleum refineries and other components of the petrochemical industry. In addition, the study area is exposed to a general background of odor associated with Los Angeles air pollution, including automobile exhaust.

The specific purpose of the study in Carson was to estimate the annoyance reactions and possible health effects of exposure to odor in this community and to determine whether annoyance and health reactions are related to measurements made by dynamic olfactometry as previously reported in the pulp mill studies. The general background and rationale behind community odor studies has been described in more detail in previous studies.[4,5]

METHODOLOGY AND MATERIALS

Distinguishing Features of the Carson Study

As mentioned above, although the basic methodology of the study was the same as that used in the studies of the effects of pulp mill odor, the situation being studied differed in several respects. These are summarized as follows:

1. Several refineries and petrochemical plants are located in the immediate vicinity of the study area as well as in the general region.
2. A background of Los Angeles smog exists, including odorous automobile exhaust.
3. The odorous emissions of the refineries tend to be sporadic.
4. The odor appears to be neither as pervasive nor as objectionable as the odor from pulp mills.

Sampling

As in the pulp mill odor studies, three residential areas were chosen that were presumed to have different exposures to the odors from the refineries and petrochemical plants on the basis of location with respect to the plants and the prevailing winds. The relative location of the principal sources of odor in the three areas is shown in Figure 1. The areas were selected on the basis of similar housing type and quality, which suggested that the areas were of comparable socio-economic status.

About 100 households were chosen in each of the areas by systematic random sampling. This represents about twice the number of households used in the pulp mill studies; it was hoped that the augmentation of the sample size would enable the investigators to detect meaningful statistically significant differences in the prevalence of infrequently reported symptoms as well as permit analysis separately by sex for those symptoms which exhibit significant differences in frequency in men and women. The initial samples were designed to include approximately equal numbers of men and women in each area. It was determined randomly whether a man or a woman, usually the head of household or his spouse, was to be interviewed in each household, but if an adult of the designated sex was not living in the household, any adult living there was interviewed. The final sex distribution of the respondents, therefore, should represent the population distribution by sex within each area.

The sample sizes, the distribution by sex, and the proportion of interviews successfully completed are shown in Table 1. The original samples were augmented to replace unoccupied households. The sample sizes include these and represent the total numbers of houses approached. The nonrespondents represent a total of five households in which the respondent refused to be interviewed after repeated attempts and four additional households in which it was not possible to contact the respondent at all.

Exposure Data

The exposure to odor in the three areas was estimated by dynamic olfactometry. The measurements are based on the "odor dilution factor" which is the ratio of ambient air (air to which the community is exposed) to odorless air at which a trained observer just detects odor. This is converted to the equivalent of parts per billion of a specific odorant by multiplying by the odor threshold of each observer, which is the ratio of known dilution of a specific odorant to odorless air at which the observer just detects the odor.

The sensitivity of the method is a function of the observer's odor threshold and the lowest dilution of odorant to odorless air that can be measured on the olfactometer. In order to sample the ambient air adequately, daily observations were obtained during a two-week period in March. Observations were taken by two observers at several sites in each of the three areas at half hour intervals between 8 a.m. and midnight. The sampling sites, the method of sampling the ambient air, and the instrumentation and technique of using the olfactometer are described in detail elsewhere.[7,8] The odor threshold of each observer was measured twice a day, at the beginning and end of each shift. Two shifts per day were used, from 0800 to 1500 and from 1500 to 2400, respectively, with a relief observer to serve during the lunch and dinner hours.

Questionnaire and Interviewing

The questionnaire was similar to that used in the second pulp mill odor study in Eureka, California[5], with suitable modifications made to replace references to pulp mill odor with references to odors from industry. The first section deals with such background data as age, occupation and family structure; the second section with satisfaction with general conditions in the residential area and the community; and the third section with air pollution and noise problems in the area. The questions designed to measure annoyance to odor from industries occur in the fourth section. Questions were not asked specifically about odors from refineries or the petrochemical industry because it was felt that respondents could not distinguish the type of industrial odor with sufficient reliability. This marks a departure from the design of this section of the questionnaire as originally used in the pulp mill odor studies, in which the respondent was first asked about reactions to industrial odor in general, and if pulp mill odor was not mentioned voluntarily, was then asked specifically about reactions to pulp mill odor. The fifth section of the questionnaire consists of question designed to measure attitudes toward pollution and noise problems in general. The sixth section consists of questions on cough, phlegm, and shortness of breath from the British Medical Research Council's (MRC) questionnaire on respiratory symptoms.[9] The final section contains a list of symptoms which the respondent is asked to specify as being experienced "frequently", "occasionally", or "hardly ever". No specific reference to odor or air pollution was made in asking the health questions. The average time required for interviewing was between 15 and 20 minutes. The interviewing was carried out during March and April 1972.

A training period of two to three days at the beginning of the field work included detailed explanation and discussion of each item in the questionnaire and the method of recording responses as well as practice in using the questionnaire by means of role playing. The practice interviews were recorded on tape and replayed for correction of errors and discussion of interviewing technique. This was followed by actual practice field interviews which were edited for omissions, inconsistencies, and errors in recording responses. Similar editing was done during the survey itself so that errors could be corrected while the field work was still in progress and interviewer performance could be evaluated and modified if necessary.

The interview was introduced to the respondents as part of a survey on health as well as on how people feel about the community in which they live. In order to mask the principal aim of this study, community odor or air pollution problems were not mentioned in the introduction. This is important in obtaining unbiased results.[10]

Statistical Analysis

The basic hypotheses being tested are that area trends exist in the annoyance and health reactions, with Area I having the highest percent of respondents reporting reactions and Area III the lowest. The test used is the χ^2 for trend test described by Armitage.[11] In this application, an assumption of linearity of trend is made, and equally-spaced scores are chosen to represent each area. In addition to testing the statistical significance of the trend, one may also test for departure from trend by comparing the χ^2 for trend with the total 2x3 χ^2.

Other tests which could have been used to test for significant area differences include the usual total 2x3 χ^2, and pairwise testing of area differences using 2x2 χ^2 (Area I vs. Area II, Area I vs. Area III, and Area II vs. Area III). The latter method would have altered the level of significance in a manner similar to that encountered in multiple t-tests. The total 2x3 χ^2 test would not have given appropriate weight to consistencies in the direction of trend (Area I > Area II > Area III).

RESULTS OF ANNOYANCE SURVEY

The results of the annoyance survey are presented here in a format similar to that used in the reports for the results of the pulp mill surveys and can be classified into four main categories:

1. Perception of the exposure situation.
2. Annoyance reactions.
3. Implications of the annoyance reactions.
4. Relevance of the background variables to annoyance reactions.

Detailed descriptions of the responses tabulated on each table are given in the Appendix.

1. Perception of the Exposure Situation

The frequency with which odor was reported as being noticed is used as a measure of the perception of the community exposure to odor. This is shown in Table 2 and is tabulated from responses to questions asking whether the respondent has noticed the odor from industry during the last three months and, if so, how often it was noticed. Area I represents the greatest presumptive exposure to the odor; Area III the least exposure. The percents of respondents noticing the odor every day were 21 percent in Area I (20 out of 97), 15 percent in Area II (14 out of 95), and 4 percent in Area III (4 out of 99). The corresponding percents of respondents noticing the odor at least once a week (including "every day") were 50 percent, 51 percent and 16 percent while the percent of respondents who reported that they did not notice the odor at all were 12 percent in Area I, 13 percent in Area II, and 54 percent in Area III. These differences were statistically significant at the one percent level using χ^2 tests for trend. However, the differences between Areas I and II in the percents noticing the odor at least once a week and not at all are negligible when compared with the corresponding percents in Area III. This is reflected in the significant χ^2's for departure from trend for these categories.

2. Annoyance Reactions

Significant area trends are also seen with respect to the percent of respondents who reported being very much bothered by the odor and the percent very much or moderately bothered combined, but the departure from trend for the latter category is also significant, again reflecting the lack of difference between Areas I and II in this combined category (Table 3).

The response "not noticed or not bothered at all" was given by 12 percent in Area I (12 out of 97), 17 percent in Area II (16 out of 95), and 59 percent in Area III (58 out of 99), which also represents a significant trend.

Respondents who were bothered by the odor were also asked how often they were bothered. Of this group, in Area I, 31 percent (18 out of 59) were bothered "often" (at least several times a week), in Area II, 21 percent (12 out of 57) gave this response and in Area III, 13 percent (3 out of 24). Neither these differences nor those obtained by combining the "often" and "occasionally" categories show a statistically significant area trend. However, the corresponding trends based on the total numbers of responses in each area are significant (Table 4).

Those who reported being very much or moderately bothered were asked whether they thought the situation with regard to the odor was better or worse compared with the previous year. As shown on Table 5, about 80 percent of these respondents in each area thought there had been no change or answered "don't know". The 15 respondents who felt the situation was better in 1972 were about evenly divided between those who felt that the situation was better and those who thought it might have been because they had become used to it. All but 2 of the 14 individuals who thought the odor was worse in 1972 felt that this was because there was more odor rather than that they had become more sensitive to it. No statistically significant area trends were noted.

3. Implication of the Annoyance Reactions

The implications of the annoyance reactions were examined by measuring the degree of spontaneity with which the odor was mentioned and how likely the respondent was to try and change his exposure to odor. Respondents were given an opportunity to mention the odors from industry spontaneously, that is, in response to questions that did not deal specifically with air pollution or industrial odor. These included questions on what the respondent considered advantages and disadvantages of living in the area, whether they had considered moving, and whether they felt there was anything harmful in the community. They were also given the opportunity to make a probed response, that is, to give a positive answer to direct questions concerning whether they had noticed and were bothered by odors from industry. These two types of response are used as indicators of the saliency of the problem to the respondent. Significant area trends are seen in Table 6, indicating that individuals who noticed the odor in Areas I and II were more apt to mention the odor spontaneously than were similar individuals in Area III. This relationship holds among those who reported being only a little or not at all bothered by the odor (although noticing it) as well as among those who were very much or moderately bothered. No significant relationship was found between the degree to which the respondent was bothered and whether he mentioned the odor spontaneously or in response to direct questioning.

Respondents were also asked whether they had ever thought of requesting or had actually requested some authority or agency to take action concerning any of the community problems they had designated as "serious" or "somewhat serious". Positive responses mentioning community odor were tabulated as well as positive responses to an open-ended question in which the respondent gave odor as a reason for having felt like moving away from the community.

Table 7 shows that action was taken by 7 of the 151 respondents who were a little or not at all bothered, but by 25 of the 140 respondents who were very much or moderately bothered. Among those who were very much or moderately bothered, the residents of Areas I and II were more apt to take action than were those of Area III. "Action" regarding the odor is regarded as a measure of the respondent's tolerance toward the problem.

4. Relevance of the Background Variables to Annoyance Reactions

To test the possible area effect of differences in background variables on annoyance reactions, two-by-two tables were constructed comparing responses on each of the variables with the degree to which the respondent was bothered by industrial odors, and χ^2 tests with one degree of freedom were carried out. Detailed descriptions of the variables can be found by referring to the Appendix. Table 8 shows that significant χ^2 (starred) were obtained for general attitude toward odor, estimation of the odor problem in Carson, and the respondent's opinion regarding attitude of authorities toward air pollution. These variables are at least as likely to be a result of the individual's exposure to and reactions to odor in the community as to other characteristics which might bias the results. This is not necessarily true for "general attitude toward noise", which was also significantly related to the degree to which the respondent was bothered by the odor. However, an examination of area differences with respect to this variable, suggests that it was not a biasing factor, since χ^2 tests were not significant at the 5% level (4.75 on two degrees of freedom for total, 0.99 on one degree of freedom for trend). The percents reporting that they think noise in general is annoying are as follows: Area I, 45 percent; Area II, 61 percent; and Area III, 53 percent.

RESULTS OF HEALTH SURVEY

The health questionnaire is divided into two parts. One part consists of questions on cough, phlegm, and shortness of breath taken verbatim from the British Medical Research Councils (MRC) questionnaire on respiratory symptoms. The other part consists of a list of symptoms which respondents were asked to characterize as being experienced "frequently", "occasionally", or "hardly ever". In addition, the respondents were asked whether they had been sick, visited a doctor, or been in a hospital as a patient within the two weeks preceeding the interview.

The results of the questions concerning health are summarized in Tables 9 through 14. There were obvious differences in the percents of men and women reporting the various symptoms frequently or occasionally (Table 10). In at least one area, significantly greater percents of women reported nervousness; headache; dizziness, nausea, or vomiting; constipation; burning or irritation of the nose; and runny nose; but the differences were not all significant in each of the areas in which the study was carried out. Women also reported Grade 2 or greater shortness of breath significantly more frequently than men in one area. Cough Grade 2 was more frequent among men, but this result occurred only in one area and is based on small expected values. The following analysis is done separately for men and women where the number of observations permit.

χ^2 tests for area trend were done both for percent of respondents who reported symptoms frequently or occasionally and for percent reporting symptoms only frequently. They were done separately for the respondents who reported being very much or moderately bothered by the odor and those who reported being a little or not at all bothered.

The percent of respondents reporting that they experienced symptoms "frequently" and "frequently or occasionally" are shown by area for both sexes combined in Table 9. Considerable variation between areas was noted for some symptoms; however, only one symptom was found to show a statistically significant area trend. This was chest pain, which, when tested for those who reported being bothered either *frequently or occasionally* showed a significant trend in the direction *opposite* to that hypothesized on the basis of odor exposure. That is, the lowest percent of respondents reported this symptom in Area I, the area of greatest exposure, and the highest percent of respondents reported the symptom in Area III, the area of least exposure. Similar analysis of the data separately by sex showed that this trend was significant only among men (Table 10).

Area trends were also tested within groups classified by amount bothered by the odor (not shown in tables). All but one significant trend were in a direction *opposite* to that which would support the hypothesis that symptoms are reported more frequently in areas with greater exposure to the odor. These include nervousness, headache, sleeplessness, and chest pain. The one exception is dizziness, nausea, and vomiting, which showed a *positive* relationship to presumptive area exposure to odor for those reporting it *frequently* among the group very much or moderately bothered, but a negative relationship for those reporting it *frequently or occasionally* among the group a little or not at all bothered. Both of these results, however, are based upon small expected values.

For all areas combined, χ^2 tests were also done to test for the possible relationship of symptoms to the degree to which respondents reported being bothered by the odor. No significant χ^2's were obtained for individuals reporting symptoms frequently (Table 11), but among individuals reporting symptoms frequently or occasionally (Table 12), significant relationships were found between amount bothered by the odor and dizziness, nausea, or vomiting for both sexes combined; eye irritation among both men and women; and burning or irritation of the nose among women. These differences were all in the direction which would support the hypothesis that the symptoms occur more frequently among residents who are very much or moderately bothered by the odor than among those who are not. There is, however, no evidence to show whether the symptoms are caused by the odorous pollutants, by other pollutants which may occur in a pattern similar to the odor, or by other unidentified factors.

Tests for responses to the MRC questionnaire showed a significant area trend among men in a direction opposite to that hypothesized for Grade 3 or greater shortness of breath as defined in the appendix (Table 13). This result was based on small expected values. No significant area trends were found within groups classified by amount bothered (not shown on tables), nor were there any significant relationships between responses to the MRC questions and the amount bothered when tested for all areas combined (Table 14).

Although the interviewers were trained in the use of the MRC questionnaire using standardized methods, slightly modified probing rules were used to simplify training. Therefore, the prevalence of symptoms shown in Tables 13 and 14 should not be compared directly with the results of other surveys using the standardized questions. In addition, although the MRC questions preceded the questions concerning the frequency of other symptoms, they followed the annoyance section of the questionnaire, and this could also have affected the results.

Tables 13 and 14 also show the percent of positive responses to questions on illness, visits to a doctor, and admission to a hospital during the two weeks preceeding the interview. No significant area differences were noted, but a significant relationship was found between the sex of the respondent and whether he or she had visited a doctor during the last two weeks. The proportion of women who gave a positive response to the question "have you been to a doctor within the last two weeks?" was 29% compared to 13% of the men. A possible explanation of the high rate among women is that it includes visits to a doctor to obtain medical attention for another member of the family. It may, therefore, be a reflection of the relatively large proportion of families with young children. However, this does not invalidate the question as a device for making area comparisons of family illness.

RESULTS OF EXPOSURE MEASUREMENTS

Detailed results of the exposure measurements made by dynamic olfactometry will be presented in a separate report. However, the most important results relevant to evaluation of the annoyance reactions, are shown in Tables 15, 16, and 17, which show, respectively, the percent of total observations which indicated detection of odor, diurnal odor concentration at the 95th percentile, and the maximum odor concentration detected.

The percent of measurable odor detections shown in Table 15, indicates that odor was detected by dynamic olfactometry in almost 100% of the observations in all three areas. The only observations during which odor was not detected occurred after 5:00 p.m., and there were very few.

Combining data from all days, the 95th percentiles for each hour are shown by area in Table 16. There is little difference in the means of these 95th percentiles, which are shown with their standard errors at the bottom of the table. The distributions are likewise similar (not shown here). The means of the maximum values for each hour are shown in Table 17. If one assumes that area differences in exposure to odor do exist in the present study, and this is supported by the annoyance reactions, one must conclude that dynamic olfactometry is not a suitable method for demonstrating them in communities exposed to multiple diffuse sources of odor. This may be because the method was designed to measure exposure from one or two well-defined point sources, or it could be a function of the type of odor present.

SUMMARY AND CONCLUSIONS

The hypothesized differences between areas with respect to exposure to odor from industrial sources appears to be confirmed by the area differences in perception of the exposure situation (degree to which the odor was noticed) and annoyance reactions (degree to which and frequency with which the respondents reported being bothered by the odor). Some combinations of the response categories, however, showed little or no difference between Areas I and II, the areas of greatest and moderate exposure to the odor. Geographically, Areas I and II are adjacent, Area II being farther from the sources of odor and at a slightly higher elevation. Among those who reported noticing the odor, a similar area gradient occurred in the spontaneity with with the odor was mentioned (a measure of the saliency of the problem to the respondent). The residents of Area I and II were also more apt to have taken some action motivated by the odor (a measure of lack of tolerance toward the problem). To test the possibility that apparent area differences in these responses might reflect demographic and other individual differences rather than a true area effect, a series of χ^2 tests was carried out comparing responses to the annoyance questions with these background variables. No evidence was found to indicate that the area differences were an effect of the background variables.

Only one significant area trend was found in responses to the health questions to support the hypothesis that the exposure to odor is related to medical symptoms, as measured by the health questionnaire. This was for dizziness, nausea, or vomiting, which showed a significant relationship to exposure to odor in the percent who reported it frequently among those very much or moderately bothered by the odor. The results, however, are based on small expected values. For all areas combined, significant relationships were found between the amount by which the respondent reported being bothered by the odor and the precents reporting certain symptoms frequently or occasionally. These were dizziness, nausea, or vomiting; eye irritation; and burning or irritatation of the nose. Although these findings would support the hypothesis that the odorous pollutants are a causative factor in producing these symptoms, several other possibilities should be considered. The symptoms could be caused by other pollutants which may occur in a pattern similar to the odor, they could be caused by some unidentified third factor, or the same respondents may tend both to complain of the odor and to complain of their symptoms (reflecting a general tendency to verbalize or complain). In any event, statistically significant association alone is not proof of causation.

The results of the measurements of exposure to odor made by dynamic olfactometry indicate that this is not a very useful method of measuring the exposure to community odor from multiple diffuse sources. The method was originally designed as a measure of exposure to point sources and appears to fulfill this function well, especially as regards the presence or absence of odor.

The large differences found between the percents of men and women reporting certain symptoms point out the importance of either doing the analyses separately by sex or designing the sample in such a way that the proportions of men and women are the same in the subpopulations being compared.

Table 1

DESCRIPTION OF POPULATION SAMPLES
CARSON, 1972

	AREA I			AREA II			AREA III		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Original Sample	102	45	55	102	43	57	100	46	54
Respondents	97	44	53	95	41	54	99	46	53
Non Respondents	3	1	2	5	2	3	1		1
Refusals	1		1	3	1	2	1		1
Unable to Contact	2	1	1	2	1	1			
Vacant Houses	2	na	na	2	na	na		na	na

na = Not applicable.

Table 2

FREQUENCY WITH WHICH ODOR FROM INDUSTRY WAS NOTICED
CARSON, 1972

	AREA I	AREA II	AREA III
Total	97	95	99
Every Day	20	14	4
At Least Once a Week	28	34	12
At Least Once a Month	23	21	10
Less Often or Don't Know	14	14	20
Not Noticed at All	12	12	53

	Degrees of Freedom	Every Day or Once a Week	Every Day	Not Noticed at All
χ^2 Total	2	31.6**	12.2**	56.5**
χ^2 For Trend	1	23.1**	11.9**	43.0**
χ^2 For Departure From Trend	1	8.5**	0.3	13.5**

** Significant at the 1% level.

Table 3

AMOUNT BOTHERED BY ODOR FROM INDUSTRY CARSON, 1972

	AREA I	AREA II	AREA III
Total	97	95	99
Odor Noticed	85	83	46
Very Much Bothered	44	31	10
Moderately Bothered	15	26	14
A Little Bothered	26	22	17
Not at All Bothered or Don't Know		4	5
Odor Not Noticed or Don't Know	12	12	53

	Degrees of Freedom	Very Much or Moderately Bothered	Very Much Bothered	Not at All Bothered or Odor Not Noticed
χ^2 Total	2	22.3**	30.3**	61.2**
χ^2 For Trend	1	16.8**	29.5**	50.5**
χ^2 For Departure From Trend	1	5.5*	0.8	10.7**

* Statistically significant at the 5% level.

** Statistically significant at the 1% level.

Table 4

FREQUENCY WITH WHICH BOTHERED BY ODOR FROM INDUSTRY CARSON, 1972

	AREA I	AREA II	AREA III
Total	97	95	99
Very Much or Moderately Bothered	59	57	24
Often	18	12	3
Occasionally	23	26	8
Seldom	18	19	13
Only a Little, or Not at All	38	38	75

	Degrees of Freedom	Often	Often or Occasionally
χ^2 Total	2	12.0**	27.7**
χ^2 For Trend	1	11.8**	22.4**
χ^2 For Departure From Trend	1	0.2	5.3*

* Significant at the 5% level.
** Significant at the 1% level.

χ^2 tests based on total number of respondents.

Table 5

ESTIMATION ON CHANGE IN ODOR FROM INDUSTRY SINCE PREVIOUS YEAR
CARSON, 1972

	AREA I	AREA II	AREA III
Total	97	95	99
Very Much or Moderately Bothered	59	57	24
No Change or Don't Know	46	45	19[a]
Better Less Odor	4	3	1
Use to it	1	6	
Worse More Odor	7	3	2
More Sensitive	1		1
Only a Little or Not Bothered at All, Odor Not Noticed, or Don't Know	38	38	75

[a] Includes one "no response".

Table 6

SPONTANEITY OF MENTION OF ODOR FROM INDUSTRY BY AMOUNT BOTHERED CARSON, 1972

	AREA I		AREA II		AREA III	
	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered
Total	59	38	57	38	24	75
Spontaneous Mention of Odor	27	10	26	10	4	1
Probed Mention of Odor	32	16	31	18	20	22
No Mention of Odor	–	12	–	10	–	52

		Spontaneous vs Probed	
	Degrees of Freedom	Within Very Much or Moderately Bothered	Within Little or Not at All Bothered
χ^2 Total	2	6.94*	8.74*
χ^2 For Trend	1	6.90**	6.90**
χ^2 For Departure From Trend	1	0.04	1.84

* Significant at the 5% level.
** Significant at the 1% level.

Table 7

ACTION CONCERNING ODOR PROBLEM BY EXTENT TO WHICH BOTHERED BY ODOR FROM INDUSTRY
CARSON, 1972

	AREA I		AREA II		AREA III	
	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered	Very Much or Moderately Bothered	Little or Not at All Bothered
Total	59	38	57	38	24	75
Action Taken	11	2	12	1	2	4
Action Thought of	4	--	4	1	1	1
Neither	44	36	41	36	21	70

Note: Question concerning action was asked only of respondents who had indicated that they thought a serious or somewhat serious problem (not limited to odor) existed in the community. Others were included in the "neither" category.

Table 8

χ^2 TESTS OF BACKGROUND VARIABLES
(ONE DEGREE OF FREEDOM)
CARSON, 1972

VARIABLE	Very Much or Moderately Bothered	Other	χ^2 (1 Degree of Freedom)
Sex			
Male	60	71	0.35
Female	80	80	
Age			
<50 years	126	124	3.10
≥ 50 years	14	27	
Marital Status			
Married	121	131	0.01
Other	19	20	
Occupation			
White collar	40	32	1.75
Other (blue collar and professional)	100	119	
Job Associated With Petrochemical Industry (respondent or spouse)			
Yes	4	1	0.97
No	136	150	
General Attitude Toward Odor			
Annoying	126	85	
Not too annoying or not annoying at all	14	66	39.74**
General Attitude Toward Noise			
Annoying	85	69	
Not too annoying or not annoying at all	55	82	5.99*
Estimation of Odor Problem in Carson			
Greater than other cities its size	66	24	31.76**
Other	74	127	
Estimation of Noise Problem in Carson			
Less than other cities its size	31	31	
Other	109	120	0.04
Attitude of Authorities Toward Air Pollution			
Too little concerned	85	70	5.45*
Other	55	81	

Table 8 (Continued)

χ^2 TESTS OF BACKGROUND VARIABLES
(ONE DEGREE OF FREEDOM)
CARSON, 1972

VARIABLE	Very Much or Moderately Bothered	Other	χ^2 (1 Degree of Freedom)
Household Structure			
Adults only	28	46	3.66
Children	112	105	
Satisfaction With Community			
Things other than odor from industry don't like	101	102	
Other	39	49	0.53
Housing Index			
1 2	59	64	0.01
3 5	81	87	
Concern About Other Community Problems			
At least one other problem rated serious/somewhat serious	105	104	1.06
Other	35	47	
Exposure (hours/day)			
Six hours or less	81	76	1.37
Other	59	75	
How Long in Area			
Same residential area <1 year	13	21	1.09
Same residential area >1 year	127	130	
Action Taken on Other Community Problems (writing or phoning an official, signing a petition, or attending a meeting)			
Yes	50	39	
No	90	112	2.90

* Significant at 5% level.
** Significant at 1% level.

Table 9

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY AND FREQUENTLY OR OCCASIONALLY CARSON, 1972

	FREQUENTLY				FREQUENTLY OR OCCASIONALLY			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	291	97	95	99	291	97	95	99
Nervousness	25.8	25.8	22.1	29.3	52.9	55.7	48.4	54.5
Headache	11.7	12.4	6.3	16.2	48.8	47.4	50.5	48.5
Sleeplessness	7.6	6.2	6.3	10.1	33.3	33.0	37.9	29.3
Dizziness, nausea, or vomiting	4.5	6.2	3.2	4.0	12.7	11.3	12.6	14.1
Constipation	4.1	3.1	2.1	7.1	17.9	14.4	21.1	18.2
Pain in Joints	11.0	13.4	7.4	12.1	31.6	33.0	19.5	32.3
Difficulty in Urinating	2.1	1.0	1.1	4.0	5.5	5.2	5.3	6.1
Sinus Congestion	13.1	11.3	13.7	14.1	36.8	35.1	40.0	35.4
Eye Irritation	19.6	19.6	18.9	20.2	57.0	57.7	64.2	49.5
Burning or Irritation of the Nose	4.8	4.1	6.3	4.0	19.9	16.5	25.3	18.2
Runny Nose	8.2	7.2	5.3	12.1	28.2	26.8	28.4	29.3
Chest Pain**	2.7	2.1	0.0	6.1	15.8	9.3	13.7	24.2

** χ^2 for trend for percent reporting sympton frequently or occassionally is significant at 1% level (8.27 with 1 degree of freedom) but direction of trend is opposite to that hypothesized.

Table 10

PERCENT OF RESPONDENTS REPORTING SYMPTOMS FREQUENTLY OR OCCASIONALLY BY SEX AND AREA CARSON, 1972

AREA	MALE				FEMALE			
	Total	Area I	Area II	Area III	Total	Area I	Area II	Area III
Number of Respondents	131	44	41	46	160	53	54	53
Nervousness	42.7	40.9	43.9	43.5	61.2	67.9	51.9	64.2
Headache	40.5	34.1	53.7	34.8	55.6	58.5	48.1	60.4
Sleeplessness	30.5	31.8	39.0	21.7	35.6	34.0	37.0	35.8
Dizziness, nausea, or vomiting	7.6	4.5	12.2	6.5	16.9	17.0	13.0	20.8
Constipation	14.5	13.6	22.0	8.7	20.6	15.1	20.4	26.4
Pain in Joints	28.2	34.1	26.8	23.9	34.4	32.1	31.5	39.6
Difficulty in Urinating	5.3	6.8	4.9	4.3	5.6	3.8	5.6	7.5
Sinus Congestion	37.4	31.8	46.3	34.8	36.2	37.7	35.2	35.8
Eye Irritation	56.5	56.8	63.4	50.0	57.5	58.5	64.8	49.1
Burning or Irritation of the Nose	13.7	11.4	12.2	17.4	25.0	20.8	35.2	18.9
Runny Nose	23.7	15.9	31.7	23.9	31.9	35.8	25.9	34.0
Chest Pain*	15.3	6.8	14.6	23.9	16.2	11.3	13.0	24.5

* χ^2 for trend among males is significant at 5% level (5.09 with 1 degree of freedom), but direction of trend is opposite to that hypothesized

Table 11

*PERCENT REPORTING SYMPTOMS FREQUENTLY BY SEX AND AMOUNT BOTHERED BY ODOR
CARSON, 1972

	TOTAL			MALE			FEMALE		
	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered
Number of Respondents	291	140	151	131	60	71	160	80	80
Nervousness	25.8	26.4	25.2	21.4	18.3	23.9	29.4	32.5	26.2
Headache	11.7	11.4	11.9	8.4	8.3	8.5	14.4	13.8	15.0
Sleeplessness	7.6	8.6	6.6	6.9	8.3	5.6	8.1	8.8	7.5
Dizziness, nausea, or vomiting	4.5	5.7	3.3	3.1	3.3	2.8	5.6	7.5	3.8
Constipation	4.1	4.3	4.0	2.3	1.7	2.8	5.6	6.2	5.0
Pain in Joints	11.0	11.4	10.6	8.4	6.7	9.9	13.1	15.0	11.2
Difficulty in Urinating	2.1	1.4	2.6	0.8	0.0	1.4	3.1	2.5	3.8
Sinus Conjestion	13.1	15.0	11.3	13.0	13.3	12.7	13.1	16.2	10.0
Eye Irritation	19.6	22.9	16.6	19.8	25.0	15.5	19.4	21.2	17.5
Burning or Irritation of the Nose	4.8	5.7	4.0	3.8	3.3	4.2	5.6	7.5	3.8
Runny Nose	8.2	10.7	6.0	6.1	5.0	7.0	10.0	15.0	5.0
Chest Pain	1.7	2.7	3.3	3.8	1.7	5.6	1.9	2.5	1.2

* No χ^2 tests for relationship between amount bothered by odor and percent reporting symptoms were significant.

Table 12

*PERCENT REPORTING SYMPTOMS FREQUENTLY OR OCCASIONALLY BY SEX AND AMOUNT BOTHERED BY ODOR
CARSON, 1972

	TOTAL			MALE			FEMALE		
	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered
Number of Respondents	291	140	151	131	60	71	160	80	80
Nervousness	52.9	54.3	51.7	42.7	38.3	46.5	61.2	66.2	56.2
Headache	48.8	50.7	47.0	40.5	43.3	38.0	55.6	56.2	55.0
Sleeplessness	33.3	37.9	29.1	30.5	38.3	23.9	35.6	37.5	33.8
Dizziness, nausea, or vomiting*	12.7	17.1	8.6	7.6	10.0	5.6	16.9	22.5	11.2
Constipation	17.9	20.0	15.9	14.5	16.7	12.7	20.6	22.5	18.8
Pain in Joints	31.6	32.9	30.5	28.2	25.0	31.0	34.4	38.8	30.0
Difficulty in Urinating	5.5	6.4	4.6	5.3	5.0	5.6	5.6	7.5	3.8
Sinus Congestion	36.8	42.1	31.8	37.4	41.7	33.8	36.2	42.5	30.0
Eye Irritation**	57.0	67.9	47.0	56.5	68.3	46.5	57.5	67.5	47.5
Burning or Irritation of the Nose***	19.9	25.0	15.2	13.7	13.3	14.1	25.0	33.8	16.2
Runny Nose	28.2	27.9	28.5	23.7	21.7	25.4	31.9	32.5	31.2
Chest Pain	15.8	15.7	15.9	15.3	13.3	16.9	16.2	17.5	15.0

* χ^2 for relationship between amount bothered by odor and percent reporting symptoms significant at 5% level for both sexes combined (4.03 with 1 degree of freedom).

** χ^2 significant at 1% level for both sexes combined (12.04 with 1 degree of freedom), and at 5% level for males (5.46 with 1 degree of freedom) and females (5.75 with 1 degree of freedom).

*** χ^2 significant at the 5% level for females (5.63 with 1 degree of freedom).

Table 13

PERCENT REPORTING COUGH, PHLEGM, SHORTNESS OF BREATH, AND ILLNESS OR VISITS TO A DOCTOR OR HOSPITAL WITHIN THE LAST TWO WEEKS
CARSON, 1972

	TOTAL			MALE			FEMALE		
	Area I	Area II	Area III	Area I	Area II	Area III	Area I	Area II	Area III
Numbers of Observations	97	95	99	44	41	46	53	54	53
Cough Grade 1 or 2	18.6	14.7	20.2	18.2	14.6	26.1	18.9	14.8	15.1
Cough Grade 2	5.2	8.4	8.1	4.5	9.8	15.2	5.7	7.4	1.9
Phlegm Grade 1 or 2	17.5	18.9	18.2	20.5	19.5	23.9	15.1	18.5	13.2
Phlegm Grade 2	3.1	5.3	9.1	4.5	4.9	15.2	1.9	5.6	3.8
Persistent Cough and Phlegm	9.3	8.4	12.1	9.1	7.3	17.4	9.4	9.3	7.5
Shortness of Breath									
Grade 2 or Greater	30.9	24.2	37.4	18.2	19.5	34.8	41.5	27.8	39.6
Grade 3 or Greater*	8.2	8.4	13.1	2.3	4.9	13.0	13.2	11.1	13.2
Sick Within Last 2 Weeks	13.4	20.0	17.2	6.8	22.0	15.2	18.9	18.5	18.9
Saw Doctor Within Last 2 Weeks	19.6	17.9	27.3	13.6	9.8	15.2	24.5	24.1	37.7
Patient in Hospital Within Last 2 Weeks	2.1	4.2	2.0	2.3	4.9	2.2	1.9	3.7	1.9

* χ^2 for trend significant at 5% level for males (4.11 with 1 degree of freedom), but direction of trend is opposite to that hypothesized.

Note: The following χ^2 show significant differences by sex:

	χ^2	Degrees of freedom
Shortness of breath Grade 2 or greater		
Area I	5.08*	1
All areas combined	4.18*	1
Visits to doctor within the last 2 weeks		
Area III	5.21*	1
All areas combined	9.65**	1

* Significant at the 5% level.
** Significant at the 1% level.

Table 14

PERCENT REPORTING COUGH OR PHLEGM, SHORTNESS OF BREATH, AND ILLNESS OR VISITS TO A DOCTOR OR HOSPITAL WITHIN THE LAST TWO WEEKS
CARSON, 1972

	BOTH SEXES			MALE			FEMALE		
	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered	Total	Very Much or Moderately Bothered	Little or Not at All Bothered
Numbers of Observations	291	140	151	131	60	71	160	80	80
Cough Grade 1 or 2	17.9	19.3	16.6	19.8	18.3	21.1	16.2	20.0	12.5
Cough Grade 2	7.2	8.6	6.0	9.9	8.3	11.3	5.0	8.8	1.2
Phlegm Grade 1 or 2	18.2	20.7	15.9	21.4	21.7	21.1	15.6	20.0	11.2
Phlegm Grade 2	5.8	5.7	6.0	8.4	6.7	9.9	3.8	5.0	2.5
Persistent Cough and Phlegm	10.0	11.4	8.6	11.4	10.0	12.7	8.8	12.5	5.0
Shortness of Breath									
Grade 2 or Greater	30.9	32.9	29.1	24.4	23.3	25.4	36.2	40.0	32.5
Grade 3 or Greater	10.0	8.6	11.3	6.1	1.7	9.9	12.5	13.8	11.2
Sick Within Last 2 Weeks	16.8	20.0	13.9	14.5	15.0	14.1	18.8	23.8	13.8
Saw Doctor Within Last 2 Weeks	21.6	23.6	19.9	13.0	15.0	11.3	28.8	30.0	27.5
Patient in Hospital Within Last 2 Weeks	2.7	2.1	3.3	3.1	3.3	2.8	2.5	1.2	3.8

Note: No χ^2 tests for amount bothered by odor and percent reporting symptoms were significant.

Table 15

PERCENT MEASURABLE ODOR DETECTIONS
(ODOR FREQUENCY)
CARSON, 1972

TIME OF DAY	AREA I		AREA II		AREA III	
	Total Number of Observations	Percent of Observations With Odor	Total Number of Observations	Percent of Observations With Odor	Total Number of Observations	Percent of Observations With Odor
Total 0800-2400	917	99.78	880	99.89	1190	99.92
0800-1130	248	100.00	242	100.00	332	100.00
1200-1630	271	100.00	262	100.00	376	100.00
1700-2400	398	99.50	376	99.73	482	99.79

Table 16

DIURNAL ODOR CONCENTRATION AT 95th PERCENTILE BY AREA AND TIME (AS ppb CH_3SH) CARSON, 1972

TIME OF DAY	AREA I	AREA II	AREA III
0800	420.0	67.4	102.1
0830	67.8	321.7	77.3
0900	98.6	59.2	253.8
0930	410.5	62.3	60.1
1000	71.0	407.8	73.4
1030	88.2	88.0	472.2
1100	125.8	121.2	100.4
1130	198.3	88.6	126.3
1200	81.1	92.5	81.2
1230	71.1	100.4	76.2
1300	83.3	143.4	87.2
1330	58.0	83.3	462.5
1400	390.3	69.8	83.3
1430	71.3	154.3	107.3
1500	63.7	118.4	102.2
1530	41.8	63.6	71.4
1600	84.8	655.6	74.4
1630	58.5	56.1	398.1
1700	127.6	133.8	88.7
1730	58.1	137.3	246.2
1800	136.2	45.6	73.3
1830	113.7	89.2	42.2
1900	43.6	68.1	94.3
1930	106.1	59.6	61.1
2000	128.3	70.2	75.3
2030	111.1	42.6	161.5
2100	88.5	82.5	45.7
2130	64.3	67.7	168.5
2200	48.8	69.7	78.6
2230	68.0	61.7	86.8
Mean	119.28	122.72	134.39
s	103.09	127.01	116.43
N	30	30	30
SE_x	18.82	23.19	21.26

Table 17

MAXIMUM ODOR CONCENTRATION DETECTED BY AREA AND TIME (AS ppb CH_3SH) CARSON, 1972

SAMPLING INTERVAL BEGUN AT	AREA I	AREA II	AREA III
0800	915.1	74.5	141.6
0830	156.5	528.6	133.4
0900	133.4	71.5	413.7
0930	520.1	70.7	71.5
1000	105.5	448.1	77.3
1030	97.5	148.8	597.0
1100	192.8	356.4	223.0
1130	234.6	114.6	356.4
1200	118.9	202.9	149.8
1230	89.6	141.3	111.8
1300	85.4	237.6	97.5
1330	74.5	152.4	657.8
1400	393.6	115.1	100.5
1430	109.4	260.7	312.0
1500	92.4	221.8	193.2
1530	42.0	66.7	80.3
1600	113.2	713.0	95.8
1630	73.4	82.0	713.0
1700	204.8	158.2	113.2
1730	80.3	128.3	331.6
1800	250.0	49.5	95.1
1830	451.0	113.1	60.8
1900	53.2	110.1	157.9
1930	198.0	99.8	63.8
2000	253.2	89.7	85.3
2030	153.9	44.9	577.1
2100	290.2	150.1	52.7
2130	98.7	72.5	274.6
2200	57.6	73.5	88.7
2230	104.6	87.1	114.7
Mean	191.45	172.78	218.04
s	180.63	153.46	192.71
N	30	30	30
SE_x	32.98	28.02	35.18

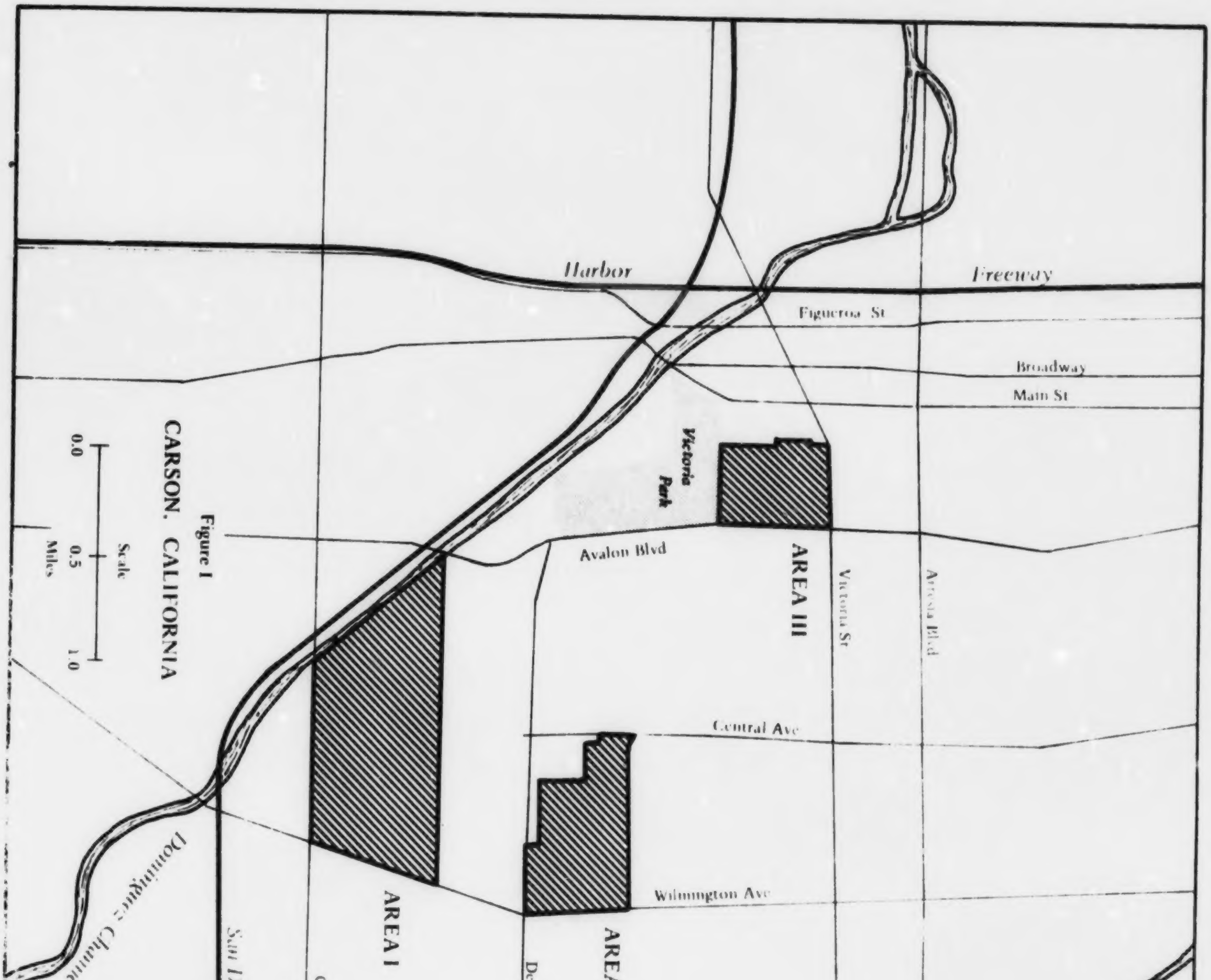

Figure I
CARSON, CALIFORNIA

Scale
0.0
0.5
1.0
Miles
Harbor
Freeway
Figueroa St
Broadway
Main St
Victoria Park
AREA III
Avalon Blvd
Victoria St
Artesia Blvd
Central Ave
Wilmington Ave
AREA II
AREA I
Del Amino Blvd
Carson St
Dominguez Channel
San Diego Freeway
405
7
Long Beach Freeway
Los Angeles River

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CARSON COMMUNITY ODOR STUDY

APPENDIX

Definitions of Analytic and Background Variables

Table 2

Positive responses to two questions were used to measure the frequency with which odor from industries was noticed by the respondent:

A. "Have you noticed odors from industries here at home during the last three months?"

B. Respondents who gave a positive response were asked: "How often? Is it every day, at least once a week, at least once a month, or less often?" The "not noticed at all" category included individuals who did not know whether they had noticed the odor. (See page 12 of the questionnaire.)

Table 3

Individuals who had given positive answers to Question A (above) were classified according to the extent bothered by pulp mill odor according to responses to the following question:

C. "Would you say it has bothered you only a little, moderately, very much, not at all?" (See page 12 of questionnaire.)

Table 4

Respondents who had indicated on Question C that they were very much or moderately bothered were tabulated by "frequency with which bothered" on the basis of answers to Question B (above) and an additional question:

D. "How often has it bothered you? Is it almost every time, about half the time, less often?"

The definitions of "frequency with which bothered" in terms of responses to Questions B and D are shown below:

How Often Noticed (Question B)	How Often Bothered (Question D)	
	Almost every time or about half the time	Less Often or don't know
Every day	Often	Occasionally
At least once a week	Occasionally	Seldom
At least once a month	Seldom	Seldom
Less often or don't know	Seldom	Seldom

Table 5

Respondents who were very much or moderately bothered, as measured by responses to Question C, were categorized by responses to the following three questions:

E. "You said the odors have bothered you. Do you think it's better, worse, or the same this year as last year?" (See page 13 of the questionnaire.) If "better", question F was asked, if "worse", question G was asked.

F. "Do you think it's because there is less odor or because you have become used to it?" (See page 13 of the questionnaire.)

G. "Do you think it's because there is more odor or because you are more sensitive to it?" (See page 13 of the questionnaire.)

Table 6

Respondents were tabulated according to whether they mentioned the pulp mill odor "spontaneously" or gave a "probed" response, defined as follows:

"Spontaneous mention of odors" was defined as mention of odors in response to the following questions:

H. "What are some of the things you don't like about living here?"

I. "Have you ever felt like moving away from this residential area?" If yes, "When you have felt like moving away, what has the reason been?"

J. "If you could find a similar apartment (house) which would not be more expensive in another residential area, would you like to move there?" If yes, "why would you like to do this?"

K. "Is there anything here in the community that you think is harmful for you or your family?" If yes, "What is this?"

These questions occur early in the questionnaire before odors from industry have been mentioned by the interviewer. (See pages 4-5 of the questionnaire.)

"Probed mention of industrial odors" was defined as a positive response to the following question:

L. "Have you notice odors from industries here at home during the last three months?"

"No mention of industrial odors" was defined as a negative response to Question L with no previous mention of odors.

Table 7

Data shown on Table 7 were tabulated from positive responses, with mention of industrial odor, to the following questions:

M. "Have you ever thought of requesting, or have you actually requested some authority or agency to take action concerning any of these problems, e.g., by writing or phoning an official, signing a petition, or attending a meeting?" If so, "what problem was it?" (See page 9 of the questionnaire.)

N. "Have you ever felt like moving away from this residential area?" If yes, "when you have felt like moving away, what has the reason been?" (See page 4 of the questionnaire.)

Question M was asked only of respondents who had given a "serious" or "somewhat serious" response to the following question:

O. "Here are a few problems which different communities are facing. How would you rate each of these for Carson today in terms of serious, somewhat serious or not serious?

Outbreaks of contagious diseases, such as whooping cough, diphtheria, etc.

Water pollution.

Noise in the community or residential area.

Air pollution.

Are there any other problems which you think are serious or somewhat serious for Carson?"

Table 8

Background Variables

Satisfaction with community

Individuals who indicated on a combination of three questions that there were things other than industrial odor that they did not like about the residential area, were tested against all others. Those who didn't know whether to rate the community good, fair, or poor were included in the latter category.

Housing index was derived from the number of bedrooms in the household and the number of married couples, single adults and children. Households coded 1-2 as indicated below were tested against those coded 3-5.

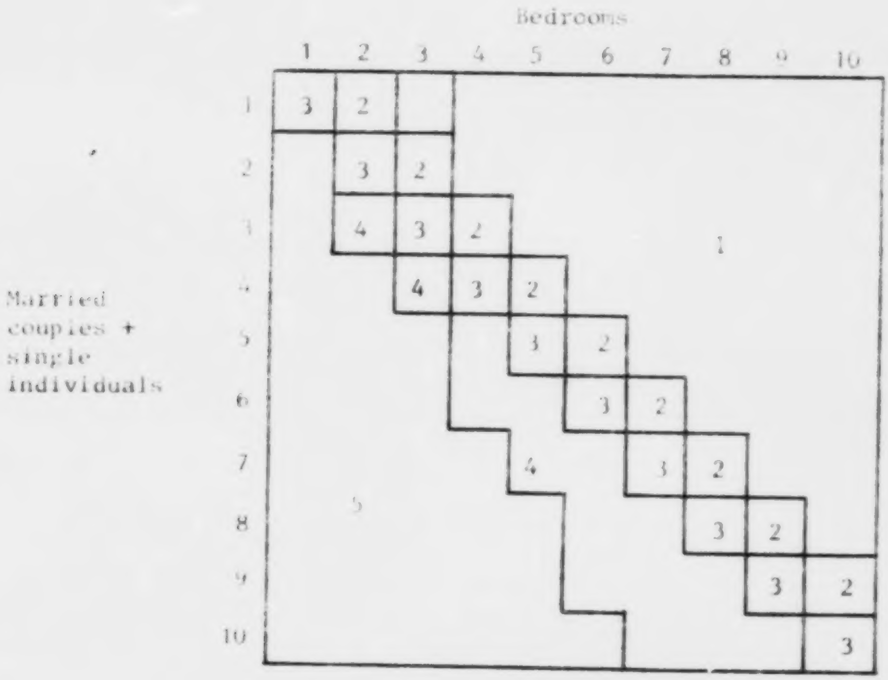

Bedrooms
1
2
3
4
5
6
7
8
9
10
Married couples + single individuals
1
2
3
4
5
6
7
8
9
10
3
2
3
2
4
3
2
1
4
3
2
3
2
3
2
4
3
2
5
3
2
3
2
3

Table 9-12

The frequency with which symptoms were reported were tablulated from responses to the following:

> "I am going to read you a list of symptoms and I should like you to tell me whether you have each one frequently, occasionally or hardly ever."

Table 13-15

The tables on cough, phlegm, and shortness of breath were tabulated from responses to the following section of the questionnaire:

PREAMBLE: "I am going to ask you some questions, mainly about your chest. I should like you to answer 'YES' or 'NO' whenever possible."

COUGH

1. "Do you usually cough first thing in the morning (on getting up)?"
   Count a cough with first smoke or on first going out of doors.
   Exclude clearing throat or a single cough.
3. "Do you usually cough during the day - or at night?"
   Ignore an occasional cough.

If 'No' to both questions 1 and 3, go to question 6.

If 'Yes' to either question 1 or 3:

5. "Do you cough like this on most days (or nights) for as much as three months each year?"

PHLEGM

6. "Do you usually bring up any phlegm from your chest first thing in the morning (on getting up)?"
Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.

8. "Do you usually bring up any phlegm from your chest during the day - or at night?"

Accept twice or more.

If 'Yes' to either question 6 or 8:

10. "Do you bring up phlegm like this on most days (or nights) for as much as three months each year?"

BREATHLESSNESS

14a "Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?"

If 'Yes' to question 14a:

14b "Do you get short of breath walking with other people of your own age on level ground?"

If 'Yes' to question 14b:

14c "Do you have to stop for breath when walking at your own pace on level ground?"

Cough, phlegm, and shortness of breath were graded as follows:

Cough Grade 0: 'No' to both questions 1 and 3 or 'no' to question 5.
Grade 1: 'Yes' to either questions 1 or 3 and 'yes' to question 5.
Grade 2: 'Yes' to both questions 1 and 3 and 'yes' to question 5.

Phlegm Grade 0: 'No' to both questions 6 and 8 or 'no' to question 10.
Grade 1: 'Yes' to either questions 6 or 8 and 'yes' to question 10.
Grade 2: 'Yes' to both questions 6 and 8 and 'yes' to question 10.

Shortness of Breath
Grade 1: 'No' to question 14a.
Grade 2: 'Yes' to question 14a and 'no' to question 14b.
Grade 3: 'Yes' to question 14b and 'no' to question 14c.
Grade 4: 'Yes' to question 14c.

SECTION VI-G

RICHMOND ODOR PANEL STUDY

I. Background

Since the best known detector of the frequency, intensity, and character of odor as it effects people is the human nose, periodic reports from a panel of community residents is a logical candidate for gathering data to be used in a surveillance system. Such a system differs from the community annoyance and health survey in that it documents reactions at specific times rather than over a period of time, as well as generating reports which are repetitive at regular intervals. Negative as well as positive reports are collected, permitting construction of rates.

II. Aims

This study was undertaken on a pilot basis primarily as a feasibility study. Thus primary emphasis in reporting results will be focussed on completeness and adequacy of reporting, problems encountered, and potential usefulness of data collected.

III. Methodology

A. Selection of Areas

Three areas of Richmond were selected to represent different exposures to odor. These were: a central area which is part of the area covered by a Model Cities program and which is exposed to odors from refineries and other industrial plants, Point Richmond, which is exposed sporadically to refinery odor, and the eastern portion of Richmond, which is expected to be relatively free from exposure to the odor.

B. Selection of Panels

Selection of individuals participating in the study was the responsibility of the Model Cities Program in central Richmond and the Contra Costa County Health Department in Point Richmond and east Richmond. Thirty participants were selected scattered throughout the central Richmond area, and an arrangement was made to pay each participant $10 per month. Ten participants each were chosen to represent Point Richmond and east Richmond; these were not paid. Selection was made on the basis of interest in the project, reliability, and probability of being at home during the required reporting times.

C. Method of Reporting

Several alternative methods of reporting were considered, including telephoning to a supervisor, having supervisors telephone to each panel member, mailing of reports to supervisors, and providing for collection of reports by supervisors. A trial period was initiated using report cards to be mailed daily in pre-addressed, prepaid postage envelopes, but this proved to be an unsatisfactory method of obtaining timely and complete reports. The method finally used was to provide for weekly pick-up and monitoring of reports by supervisors.

Each participant was asked to complete a separate form three times a day at 10 A.M., 4 P.M., and 10 P.M. The respondent was asked whether odor was noticed, if so, to what extent it bothered him, how it bothered him, where he thought the odor came from, and where he was when the odor was noticed. The last question permits separating positive responses which were made when the individual was not at home from those made elsewhere.

One of the deficiencies of the questionnaire is that the respondent was not required to fill out the remainder of the questionnaire if he indicated on the first question that he did not notice the odor at the time the report was made. Therefore for negative reports, it is not known whether the observation was made at home. This is reflected in some uncertainty in the denominator upon which rates are based.

It has been necessary to assume that negative reports were made at home unless otherwise indicated voluntarily by the panelist, and this is probably an adequate representation of the situation.

The report form also included a section for reporting of odors at times other than those for which regular reports were requested.

IV. Results

A. Completeness of Reporting

A comparison of the number of reports received per participant in each area with the target number is shown by month in Table 1. The target number of reports per person per month was obtained by multiplying the number of days for each month by three (the number of reports due for each day). The range of reports per person is large, but this is partly a reflection of reports from participants who entered the study late or dropped out before completion. No attempt was made to compensate for this. The medians, however, should not be appreciably affected. The median number of reports per person expressed as percent of target number per month ranged from 43.5 to 84.4 for central Richmond, 74.4 to 93.5 for Point Richmond, and 74.4 to 96.8 for east Richmond.

B. Percent of Positive Reports

The median percent of positive reports per person is shown by month and area in Table 2. These are not noticeably different between areas, nor is there a consistent area gradient from month to month. A considerable drop appears to occur from September to January in all three areas. Large differences occur by individual participant, however, ranging from 0.0 in each area to 81.3 in central Richmond, 60.5 in Point Richmond, and 52.4 in east Richmond.

The percents of positive reports are shown by area, time of day, and month in Table 3. Central Richmond appears to have the largest overall percent of positive reports, followed by east Richmond. However, the high percentage in central Richmond is partly a function of the high central Richmond rates for the beginning and end of the study, and could result from a selective bias. Point Richmond appears to show a relatively consistently higher percent of positive reports in the morning when compared with other times of day, while higher percents are reported from east Richmond in the late evening. No such consistent time-of-day effects are seen for central Richmond.

The degree to which respondents were bothered by the odor, physical symptoms they experienced, and the presumed source or type of odor are shown by area and time on Tables 4-6. Percents are based only on numbers of positive reports, and should be interpreted accordingly. Point Richmond had the largest percentage of positive reports in which individuals reported being very much bothered and the smallest percent not at all bothered (Table 4). East Richmond had the largest percent not at all bothered. Time of day differences were not consistent.

Relatively few of the complaints of odor refer to physical effects (Table 5). For all areas and times of day combined, nose irritation was most frequently mentioned (11.9%), followed by eye irritation (8.1%). Difficulty in breathing (6.0%), nausea (5.9%), and throat irritation (4.8%) were mentioned with about equal frequency. Headache was mentioned relatively rarely (0.9%). These represent responses to an open-ended question and are probably a conservative estimate of effects. Some area differences are evident although these should be interpreted in the light of possible socio-economic and educational differences.

Nose irritation, eye irritation, and throat irritation were mentioned most frequently in Point Richmond; nose irritation, throat irritation and difficulty in breathing in east Richmond; and nose irritation, eye irritation, and nausea in central Richmond. Time of day differences were not consistent either by symptom or by area.

For positive reports of odor, respondents were asked "where do you think the odor came from?" Replies either referred to general or specific sources or characterized the odor by type, and were coded into the categories shown on Table 6. For all areas and times of day combined, 22% said they didn't know where the odor came from or failed to answer the question. The most commonly mentioned "source" was sulfur or sulfur compounds, which characterized about 20% of the positive responses. This was followed in frequency by "burning", which represented 17%, and "other", which represented 16%.

Traffic, industrial, and odors characterized as "putrid, dump, or sewer" accounted for about 7% each. Smog accounted for 5% of the responses, and "bay" for 3%. Refineries were mentioned relatively infrequently, about 3% of the time. Very few responses mentioned specific sources of odor by company name. Area differences were marked. Sulfur or sulfur compounds were mentioned on over 50% of the positive reports from Point Richmond, burning by over 40% from east Richmond, and in central Richmond 22% were characterized as "other" and 30% by "don't know". Differences by time of day were neither large nor consistent.

Cross-tabulations of source or type of odor by physical symptoms are shown on Tables 7 and 8. These should be interpreted in the light of the marginal percents which show the percent of positive reports mentioning each category on Tables 4-6. For example, on Table 7, 25% of the responses mentioning headache attributed it to odors of sulfur, but headache was reported on less than 1% of the total positive responses (Table 5). Table 7 shows the percentage distribution by source for each symptom. Table 8 shows the percentage distribution by symptom for each source. The main features of both Table 7 and 8 can be summarized as follows. Nose irritation, which was mentioned on 12% of the positive reports, was attributed principally to burning or smoke (19%), followed by sulfur odor and traffic (17% each). Eye irritation, mentioned on 8% of the reports, was attributed primarily to smog (15%), traffic and "other industry" (13% each). Difficulty in breathing (6%) was attributed mainly to burning or smoke (29%), and sulfur and traffic (20% each).

The commonest symptom reported in response to odors of sulfur (Table 8) (reported by 21% of the positive responses) were nose irritation (10%), difficulty in breathing (6%) and nausea (5%). Burning or smoke (reported by 17%) was held responsible chiefly for nose irritation (13%) and difficulty in breathing (10%). Other or unknown odors appeared to be the cause mainly for eye irritation (21%) and nausea (21%).

Tables 9 and 10 similarly show respectively the distribution of amount bothered by source, and the distribution by source for each category of amount bothered. Thus the largest percent of reports for which the respondent was very much or moderately bothered attributed the odor to sulfur compounds (31%), while those who were only a little bothered also mentioned sulfur most often (18%). Those who were not at all bothered by the odor, although they had reported noticing it, most often attributed the odor to burning or smoke (45%).

Tables 11 and 12 show respectively distribution by symptom for each "amount bothered" category and distribution by amount bothered for each symptom. The reports indicating that respondents were very much bothered most frequently mentioned nausea (48%), followed closely by nose irritation (16%) and difficulty in breathing (15%). Being moderately bothered was associated chiefly with nose irritation (18%) and eye irritation (16%). Almost all of those who were not bothered at all indicated that they attributed no physical symptoms to the odor.

V. Discussion and Interpretation

The panel reporting system seems to offer some possibility for comparisons over time, as well as area comparisons, and for identification of offending odors and symptoms attributed to them. However, considerable difficulty was encountered in some areas in obtaining adequate and timely reports.

Also, even in the case of relatively dedicated panelists, it is unrealistic to expect continued reporting over a long period of time. Replacement of panelists raises questions concerning relative sensitivity to the odor. This problem could be approached by testing panelists for odor threshold to various substances likely to be encountered in the community. Possible differences in odor threshold in participants in the various areas may also interfere with area comparisons. Panelists were not, however, tested for odor threshold.

With the present reporting form several sources of missing values exist:

1. Participant does not report, regardless of whether he is at home.
2. Participant gives a positive report of odor, but is not at home.
3. Participant gives a negative report of odor, but is not at home. With the present form, it is impossible to ascertain whether negative reports originated at home.

The first two cases can be designated as generating "missing values", but in the third case, in the absence of other information on the reporting form, we must assume that these observations were made at home in order to obtain a denominator for rates of positive reports. This could be avoided by using as the first question "are you at home now?" or "place where report was made".

Reporting of possible sources of odor and physical symptoms might be improved by presenting respondents with check lists although possible "leading" could result from this technique.

Table 1

RANGE AND MEDIAN NUMBER OF REPORTS RECEIVED PER PERSON BY AREA AND MONTH COMPARED TO TARGET NUMBER

Richmond, 1971

	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.
Target Number of Reports Per Person	90	93	90	93	93	87
Central Richmond						
Number of Participants	31	30	28	26	6	6
Number of Reports Per Participant						
Range	7–88	6–90	7–89	7–78	61–86	11–84
Median	76	72	61.5	40.5	74	66
Percent of Target	84.4	77.4	68.3	43.5	79.6	75.9
Point Richmond						
Number of Participants	12	12	11	11	11	10
Number of Reports Per Participant						
Range	34–74	55–92	67–90	54–93	70–93	25–86
Median	67	82.5	80	76	87	78
Percent of Target	74.4	88.7	88.9	81.7	93.5	89.7
East Richmond						
Number of Participants	10	10	10	10	9	9
Number of Reports Per Participant						
Range	41–75	68–93	62–90	28–93	81–93	65–86
Median	67	81.5	85	88.5	90	80
Percent of Target	74.4	87.6	94.4	95.2	96.8	92.0

Table 2

RANGE AND MEDIAN PERCENT OF POSITIVE ODOR REPORTS AT HOME BY AREA AND MONTH BASED ON TOTAL NUMBER OF REPORTS RECEIVED

Richmond, 1971

	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.
Central Richmond						
Number of Participants	31	30	28	26	6	6
Percent Positive Reports Per Participant						
Range	0.0–70.0[a]	0.0–58.5[a]	0.0–69.0	0.0–53.7	0.0–72.4	0.0–81.3
Median	17.5	8.4	6.1	4.8	3.7	2.1
Point Richmond						
Number of Participants	12	12	11	11	11	10
Percent Positive Reports Per Participant						
Range	1.4–60.5	0.0–45.7	0.0–40.7	0.0–56.0	0.0–56.0	0.0–41.2
Median	9.6	4.9	3.8	1.6	5.7	5.2
East Richmond						
Number of Participants	10	10	10	10	9	9
Percent Positive Reports Per Participant						
Range	2.9–46.3	0.0–31.2	0.0–52.4	0.0–17.9	2.2–22.6	0.0–24.6
Median	12.8	13.6	10.4	2.9	3.3	4.7

[a] Excludes one participant who only sent in positive reports.

Table 3

PERCENT OF POSITIVE ODOR REPORTS BY AREA, TIME OF DAY, AND MONTH

Richmond, 1971

	TOTAL NUMBER OF REPORTS	NUMBER POSITIVE	PERCENT POSITIVE							
			Total	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
Total	18,585	2,272	12.2	35.0	17.1	11.6	10.8	8.4	11.9	12.2
Central Richmond										
Total	7,953	1,200	15.1	35.0	20.3	12.4	11.2	9.5	19.4	26.1
10:00 AM	2,705	430	15.9	30.0[a]	20.3	14.3	11.2	13.6	16.9	[illegible]
2:00 PM	2,598	386	14.9	34.2[a]	20.8	12.0	12.8	8.4	17.1	20.0
10:00 PM	2,650	384	14.5	41.0[a]	20.0	10.7	9.6	6.4	24.2	33.1
Point Richmond										
Total	5,004	488	9.8	NA	13.5	11.8	13.7	5.1	7.2	7.2
10:00 AM	1,670	226	13.5		18.9	18.5	17.9	6.8	9.7	9.1
2:00 PM	1,652	147	8.9		11.6	10.1	13.3	5.1	5.8	7.6
10:00 PM	1,682	115	6.8		10.1	6.9	10.0	3.4	6.0	4.7
East Richmond										
Total	5,628	584	10.4	NA	13.0	9.7	7.6	10.0	12.2	10.0
10:00 AM	1,878	131	7.0		10.0	7.2	4.3	4.9	8.5	7.1
2:00 PM	1,867	139	7.4		8.4	8.0	5.8	8.3	9.1	4.5
10:00 PM	1,883	314	16.7		20.4	13.8	12.7	16.7	18.9	18.5

[a] Based on partial month.

NA: Data not collected from these areas.

Note: The numbers of participants in each area were not constant during the seven months of the study.

Table 4

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY AMOUNT BOTHERED FOR EACH AREA AND TIME OF DAY

Richmond, 1971

	NUMBER OF POSITIVE REPORTS	PERCENT				
		Don't Know or No Answer	Not at All	Only a Little	Moderate	Very Much
Total	2,272	8.7	16.8	38.7	17.4	18.4
Central Richmond						
Total	1,200	12.7	13.6	47.6	10.2	16.0
10:00 AM	430	10.7	15.1	51.9	7.7	14.6
2:00 PM	386	7.8	14.0	46.9	12.7	18.6
10:00 PM	384	19.8	11.5	43.5	10.4	14.8
Point Richmond						
Total	488	3.9	2.0	30.9	35.5	27.7
10:00 AM	226	2.6	2.2	29.6	37.2	28.3
2:00 PM	147	6.1	1.4	28.6	38.8	25.2
10:00 PM	115	3.5	2.6	36.5	27.8	29.6
East Richmond						
Total	584	4.6	35.8	26.9	17.1	15.6
10:00 AM	131	7.6	30.5	30.5	16.8	14.5
2:00 PM	139	5.8	25.2	35.2	20.9	13.0
10:00 PM	314	2.9	42.7	21.7	15.6	17.2

Table 5

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY SYMPTOMS REPORTED FOR EACH AREA AND TIME OF DAY

Richmond, 1971

	NUMBER OF POSITIVE REPORTS	PERCENT						
		Don't Know or No Answer	Headache	Nose Irritation	Eye Irritation	Throat Irritation	Affects Breathing	Nausea
Total	2,272	70.6	0.9	11.9	8.1	4.8	6.0	5.9
Central Richmond								
Total	1,200	75.2	0.2	9.4	7.0	1.2	0.4	8.5
10:00 AM	430	75.1	0.5	8.8	8.8	1.2	0.2	8.6
2:00 PM	386	72.3	0.3	10.6	8.5	0.3	0.3	9.8
10:00 PM	384	78.4	0.0	8.9	6.2	2.1	0.8	7.0
Point Richmond								
Total	488	67.4	2.0	15.8	11.3	6.1	5.3	5.1
10:00 AM	226	70.4	2.7	16.4	10.6	7.5	2.7	5.3
2:00 PM	147	65.3	2.0	10.2	15.0	6.1	6.8	6.1
10:00 PM	115	64.3	0.9	21.7	7.8	3.5	8.7	3.5
East Richmond								
Total	584	63.9	1.2	13.9	5.8	11.1	18.2	0.2
10:00 AM	131	68.7	0.8	10.7	6.1	9.9	13.7	0.0
2:00 PM	139	57.6	2.9	15.8	8.6	10.8	20.1	0.7
10:00 PM	314	64.6	0.6	14.3	[illegible]	11.8	19.1	0.0

Note: Percents may add horizontally to more than 100 since categories are not mutually exclusive.

Table 6

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY SOURCE OR TYPE FOR EACH AREA AND TIME OF DAY

Richmond, 1971

	NUMBER OF POSITIVE REPORTS	PERCENT									
		Don't Know	Traffic	Burning	Refinery	Industrial	Sulfur Compounds	Putrid, Dump, Sewer	Bay	Smog	Other
Total	2,272	22.0	7.1	17.1	3.3	7.0	20.6	6.7	2.6	5.1	16.0
Central Richmond											
Total	1,200	29.8	4.4	9.5	0.1	5.9	15.1	10.4	3.8	3.5	21.8
10:00 AM	430	26.5	3.3	10.5	0.0	6.3	16.7	10.7	3.3	4.0	22.6
2:00 PM	386	26.9	8.3	9.8	0.0	7.3	15.5	10.6	3.4	3.9	20.7
10:00 PM	384	36.5	1.8	8.1	0.3	4.2	12.8	9.9	4.9	2.6	21.9
Point Richmond											
Total	488	11.7	3.7	5.3	10.0	9.4	52.9	1.8	0.0	7.4	12.7
10:00 AM	226	11.9	1.3	4.0	9.7	9.3	50.0	1.8	0.0	8.8	13.7
2:00 PM	147	8.2	5.4	6.1	7.5	10.9	55.1	2.0	0.0	8.2	14.3
10:00 PM	115	15.7	6.1	7.0	13.9	7.8	55.7	1.7	0.0	3.5	8.7
East Richmond											
Total	584	14.4	15.6	42.5	4.5	7.0	4.8	3.3	2.2	6.5	6.8
10:00 AM	131	16.8	7.6	36.6	5.3	9.2	4.6	1.5	2.3	7.6	13.0
2:00 PM	139	18.0	12.2	35.3	5.0	12.9	1.4	4.3	1.4	12.2	8.6
10:00 PM	314	11.8	20.4	48.1	3.8	3.5	6.4	3.5	2.5	3.5	3.5

Note: Percents may add horizontally to more than 100 since categories are not mutually exclusive.

Table 7

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY SOURCE OF ODOR FOR EACH SYMPTOM

Richmond, 1971

	DON'T KNOW OR NO ANSWER	HEADACHE	NOSE IRRITATION	EYE IRRITATION	THROAT IRRITATION	AFFECTS BREATHING	NAUSEA
Total Number of Positive Reports	1,605	20	271	184	109	137	133
Percent Each Source or Type							
Traffic	5.0	0.0	16.6	12.6	20.2	19.7	1.6
Burning or Smoke	17.3	5.0	19.2	9.8	22.0	29.2	2.4
Refineries	2.1	10.0	10.7	2.2	8.3	8.8	0.8
Other Industry	6.7	5.0	6.6	12.6	9.2	8.0	7.9
Sulfur	22.6	25.0	17.0	9.3	11.0	19.7	16.5
Putrid, Dump, Sewer	8.0	0.0	1.5	0.0	0.0	2.2	14.2
Bay	3.1	0.0	2.2	1.1	0.0	0.0	3.1
Smog	4.0	5.0	7.0	15.3	15.6	7.3	1.6
Other	14.8	20.0	14.0	18.6	5.5	3.6	48.0
Don't Know	22.0	35.0	16.2	31.7	19.3	19.7	15.7

Note: Percents may add vertically to more than 100 since categories are not mutually exclusive.

Table 8

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY SYMPTOMS REPORTED FOR EACH SOURCE

Richmond, 1971

	TOTAL NUMBER OF POSITIVE REPORTS	PERCENT						
		Don't Know or No Answer	Headache	Nose Irritation	Eye Irritation	Throat Irritation	Affects Breathing	Nausea
Traffic	499	49.4	0.0	27.8	14.2	13.6	84.6	78.4
Burning or Smoke	162	71.4	0.3	13.4	4.6	6.2	10.3	0.8
Refineries	388	43.4	2.6	38.2	5.3	11.8	15.8	1.3
Other Industry	76	68.4	0.6	11.4	14.6	6.3	7.0	6.3
Sulfur	158	77.7	1.1	9.9	3.6	2.6	5.8	4.5
Putrid, Dump, Sewer	467	83.7	0.0	2.6	0.0	0.0	2.0	11.8
Bay	153	83.1	0.0	10.2	3.4	0.0	0.0	6.8
Smog	59	55.2	0.9	16.4	24.1	14.7	8.6	1.7
Other	116	65.6	1.1	10.5	9.4	1.7	1.4	16.8
Don't Know	363	70.7	1.4	8.8	11.6	4.2	5.4	4.0

Note: Percents may add horizontally to more than 100 since categories are not mutually exclusive.

Table 9

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY SOURCE FOR EACH "AMOUNT BOTHERED" CATEGORY

Richmond, 1971

	DON'T KNOW OR NO ANSWER	NOT AT ALL	ONLY A LITTLE	MODERATELY	VERY MUCH
Total Number of Positive Reports	198	382	879	395	418
Percent					
Traffic	6.1	6.3	6.7	12.2	4.5
Burning or Smoke	7.6	44.8	12.6	8.9	13.4
Refineries	3.5	1.3	1.5	4.8	7.7
Other Industry	5.1	1.8	8.1	10.4	6.9
Sulfur	8.1	11.5	17.6	31.1	30.9
Putrid. Dump. Sewer	4.0	1.0	10.0	7.6	5.5
Bay	3.5	1.6	2.8	2.3	2.9
Smog	3.0	3.1	6.6	5.1	4.8
Other	13.1	9.4	16.3	14.2	24.4
Don't Know	52.0	22.0	22.9	14.4	12.9

Note: Percents may add vertically to more than 100 since categories are not mutually exclusive.

Table 10

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY AMOUNT BOTHERED FOR EACH SOURCE

Richmond, 1971

	TOTAL NUMBER OF POSITIVE REPORTS	PERCENT				
		Don't Know or No Answer	Not at All	Only a Little	Moderately	Very Much
Traffic	162	7.4	14.8	36.4	29.6	11.7
Burning or Smoke	388	3.9	44.1	28.6	9.0	14.4
Refineries	76	9.2	6.6	17.1	25.0	42.1
Other Industry	158	6.3	4.4	44.9	25.9	18.4
Sulfur	467	3.4	9.4	33.2	26.3	27.6
Putrid, Dump, Sewer	153	5.2	2.6	57.5	19.6	15.0
Bay	59	11.9	10.2	42.4	15.3	20.3
Smog	116	5.2	10.3	50.0	17.2	17.2
Other	363	7.2	9.9	39.4	15.4	28.1
Don't Know	499	20.6	16.8	40.3	11.4	10.8

Note: Percents may add horizontally to more than 100 since categories are not mutually exclusive.

Table 11

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY SYMPTOMS REPORTED FOR EACH AMOUNT "AMOUNT BOTHERED" CATEGORY

Richmond, 1971

	DON'T KNOW OR NO ANSWER	NOT AT ALL	ONLY A LITTLE	MODERATELY	VERY MUCH
Total Number of Positive Reports	198	382	879	393	418
Percent					
Headache	1.0	0.0	0.7	2.5	0.5
Nose Irritation	8.1	0.0	13.4	17.5	16.3
Eye Irritation	5.1	0.3	9.2	15.7	6.9
Throat Irritation	1.5	0.0	5.3	6.6	7.0
Affects Breathing	0.5	0.0	6.1	4.6	13.3
Nausea	1.5	0.0	3.6	4.8	[illegible]
Don't Know	85.9	99.7	69.5	61.5	48.3

Note: Percents may add vertically to more than 100 since categories are not mutually exclusive.

Table 12

PERCENT DISTRIBUTION OF POSITIVE ODOR REPORTS BY AMOUNT BOTHERED FOR EACH SYMPTOM REPORTED

Richmond, 1971

	TOTAL NUMBER OF POSITIVE REPORTS	PERCENT				
		Don't Know or No Answer	Not at All	Only a Little	Moderately	Very Much
Headache	20	10.0	0.0	30.0	50.0	10.0
Nose Irritation	271	5.9	0.0	43.5	25.5	25.1
Eye Irritation	183	5.5	0.5	44.3	33.9	15.8
Throat Irritation	109	2.8	0.0	43.1	23.9	30.3
Affects Breathing	137	0.7	0.0	39.4	13.1	46.7
Nausea	127	2.4	0.0	25.2	15.0	57.5
Don't Know	1,605	10.6	23.6	38.1	15.1	12.6

SECTION VI-H

EVALUATION OF AREA DIFFERENCES IN EXPOSURE TO TOTAL PARTICULATES, SO_4 AND NO_3 IN EACH COMMUNITY STUDIED

Introduction

The Medical Research Council's questionnaire on respiratory symptoms was used in the population surveys with the provision that particulates, SO_4, and NO_3 would be measured in addition to odor exposure since they could be responsible for subarea differences in respiratory symptoms. Consequently, concentrations of these pollutants were measured for each of four quarters for Anderson and Eureka and for three quarters in Carson. The dates sampled are shown on Tables 1-11, which also give the 24-hour concentrations. For convenience, these are labeled by quarters (1-4).

Methodology

A non-parametric analysis of variance by ranks (Friedman) was chosen as the statistical test so as to avoid the effects of possible non-normality of the observations and occasional extreme values. However, in interpreting the statistical findings, the magnitude and direction of differences, as well as their consistency over time, were considered.

The hypothesis being tested is that no consistant subarea differences occur for each pollutant. The results are summarized in Table 12.

Results

Subarea differences for Anderson were statistically significant at the 5% level for SO_4 for the 3rd and 4th quarters, and for NO_3 for the 1st quarter. Area 1, which has the highest exposure to odor, has the lowest exposure to SO_4 and NO_3 for the quarters showing significant differences, so the effect should be not to exaggerate health effects, but, if anything, to lessen or conceal health effects, resulting in a conservative estimate of these effects. In addition, the differences are of a magnitude not likely to be reflected in health effects.

In Eureka, subarea differences were statistically significant at the 1% level for both total particulates and SO_4 during the 4th quarter, and were in the direction which might exaggerate health effects apparently due to odor. However, these differences, with the possible exception of SO_4, would not appear to be of sufficient magnitude to be of concern.

In Carson, statistically significant differences appear for total particulates (5% level for the 2nd quarter), SO_4 (5% level for the 4th quarter), and NO_3 (1% level for the 3rd quarter and 5% level for the 4th quarter). Particulate data are not available for the 4th quarter. The data do not appear to show large enough consistent differences between areas to result in significant differences in health effects.

Summary and Discussion

Considering the direction, magnitude, and consistency of the statistically significant results, these would not appear to be an appreciable factor in any health effects observed.

This is shown more clearly on graphs (working copies only, not included here).

TABLE 1

HIGH VOLUME AIR SAMPLES ANDERSON QUARTER 1

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
09/13/71	103.1	78.0	53.7	3.0	11.2	5.4	2.0	2.4	2.1
09/14/71	92.1	63.5	44.3	2.8	5.8	6.0	1.7	3.0	2.6
09/15/71	102.9	92.0	93.2	10.6	23.1	11.9	2.8	3.0	2.4
09/16/71	102.2	57.0	44.9	7.1	3.4	12.6	1.7	2.3	2.0
09/17/71	109.0	53.3	34.0	6.8	5.8	5.1	1.3	1.4	1.7
09/18/71	364.2	62.3	76.4	12.6	11.9	15.7	2.0	2.5	2.1
09/19/71	74.5	81.5	103.4	15.3	0.5	13.3	2.1	2.1	2.3
09/20/71	70.6	65.9	69.8	6.4	10.3	12.5	1.6	2.1	2.4
09/21/71	61.5	74.2	197.1	12.1	3.2	19.2	1.7	1.1	0.7
09/22/71	57.3	110.0	142.7	22.4	20.6	5.7	1.5	1.6	1.6
09/23/71	93.7	135.1	204.4	36.4	17.2	34.3	3.5	3.2	5.1
09/24/71	153.4	125.4	157.8	23.4	19.6	21.5	5.6	6.3	7.0

TABLE 2

HIGH VOLUME AIR SAMPLES ANDERSON QUARTER 2

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
11/10/71	58.7	65.1	100.6	4.6	2.5	6.0	5.9	6.5	5.5
11/11/71	32.2	23.4	31.2	2.6	2.8	5.3	5.3	4.6	3.9
11/12/71	25.0	22.0	55.2	2.4	1.9	4.5	2.0	2.5	1.9
11/15/71	17.3	19.7	12.8	2.7	0.7	0.7	0.9	1.4	0.8
11/16/71	25.9	30.1	22.2	1.5	2.5	1.5	0.8	0.9	0.9
11/17/71	69.5	70.0	66.6	1.5	2.8	2.4	1.7	1.4	1.7
11/18/71	18.7	24.5	16.7	1.7	1.3	1.8	1.0	1.4	1.5
11/19/71	52.9	54.9	69.6	1.3	3.9	5.6	3.9	4.3	4.1
11/20/71	115.0	107.6	130.0	4.5	3.6	4.7	10.0	11.4	12.2
11/21/71	144.1	141.0	131.6	6.0	10.2	4.4	11.2	11.8	11.5

TABLE 3

HIGH VOLUME AIR SAMPLES ANDERSON QUARTER 3

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
02/11/72	43.3	97.7		4.3	9.9		2.8	2.6	
02/12/72	90.3	47.1	53.7	4.9	13.8	12.5	1.6	1.6	1.1
02/13/72	49.9	48.9	35.5	1.3	6.2	45.6	0.4	1.6	1.4
02/14/72	53.0	92.9	75.6	3.1	7.8	3.4	1.1	1.4	1.1
02/15/72	57.[illegible]	52.3	49.2	1.4	4.1	8.4	1.4	1.1	1.4
02/16/72	96.0	52.5	48.5	4.2	3.6	9.0	0.9	1.5	1.1
02/17/72	36.3	65.0	58.6	6.0	9.0	3.4	1.6	1.8	2.5
02/18/72	92.3	84.3	62.9	10.7	13.4	12.8	6.5	5.5	5.7
02/22/72	45.3	45.7	90.8	1.9	2.4	7.8	2.0	1.9	2.5
02/23/72	42.7		76.9	1.4		4.3	1.7		1.6
02/25/72	58.2	83.6	41.8	4.8	1.3	0.7	1.4	1.8	1.9

TABLE 4

HIGH VOLUME AIR SAMPLES ANDERSON QUARTER 4

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
05/05/72	26.1	43.5	44.4	0.7	3.6	5.1	2.0	1.9	2.6
05/09/72	40.5	46.1	51.9	3.3	2.4	3.6	1.1	1.4	1.2
05/10/72	38.1	37.7	36.7	1.5	2.9	2.4	1.0	1.4	1.2
05/11/72	59.5		91.3	4.5		4.5	1.0		1.5
05/12/72	61.2	55.7		4.5	5.1		1.1	1.7	
05/15/72	73.5	76.9	142.5	4.1	6.9	6.7	0.9	1.6	1.0
05/16/72	25.5	27.7	29.9	0.7	2.9	3.6	1.1	0.9	0.6
05/17/72	34.0	32.3	30.4	0.9	1.6	1.7	0.6	0.6	0.8
05/18/72	55.4	65.4	127.3	2.4	3.4	5.9	2.0	2.0	1.9
05/19/72	42.7	40.4	110.8	2.4	0.9	5.8	3.1	3.2	2.9
05/22/72	34.0	45.3	52.0	4.1	2.9	3.7	2.4	1.2	1.9

TABLE 5

HIGH VOLUME AIR SAMPLES EUREKA QUARTER 1

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
04/13/71	153.9	115.0	126.9	9.4	10.0	4.4	0.4	2.0	1.7
04/14/71	217.1	153.3	153.0	2.7	6.8	5.6	1.9	5.7	3.0
04/15/71	133.5	151.9	145.3	10.7	7.9	2.6	3.6	5.2	5.0
04/16/71	34.9	55.9	92.0	4.9	2.6	5.6	4.2	4.1	4.1
04/17/71	100.0	57.0	47.3	10.7	1.1	9.0	2.1	1.9	1.0
04/20/71	75.0	74.5	82.4	12.5	10.4	9.4	0.2	0.1	0.1
04/21/71	56.0	52.0	78.6	3.3	10.0	12.3	0.1	0.2	0.7
04/22/71	71.9	39.1	78.1	9.9	10.3	9.1	0.4	0.8	0.6
04/23/71	34.2	73.0	67.1	8.0	9.0	8.4	1.0	1.3	0.6

TABLE 6

HIGH VOLUME AIR SAMPLES EUREKA QUARTER 2

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
10/20/71	73.2	54.3	33.0	7.3	5.2	3.4	2.1	2.0	1.2
10/21/71	58.7	77.0	56.5	5.2	4.9	5.3	1.2	1.6	1.8
10/22/71	35.3	37.2	38.0	3.8	5.2	2.7	1.0	0.7	1.1
10/26/71	52.1	55.0	41.9	5.5	3.1	4.4	0.8	0.5	0.5
10/27/71	59.0	54.9	44.8	7.5	6.1	6.8	0.5	1.5	1.2
10/28/71	59.5	66.6	62.3	5.3	5.1	4.8	1.5	1.5	1.5
10/29/71	58.5	69.3	62.5	5.4	4.2	2.8	2.6	2.7	2.4
11/01/71	55.7	52.2		6.1	3.5		2.2	1.4	
11/02/71	77.4	76.2	71.9	4.7	6.9	5.2	1.6	1.9	1.9
11/03/71	80.0	81.6	91.3	5.8	3.5	2.9	1.1	1.8	1.8

TABLE 7

HIGH VOLUME AIR SAMPLES EUREKA QUARTER 3

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA II
01/24/72	25.7	21.7	25.3	7.1	5.8	5.0	0.4	0.4	1.2
01/25/72	20.4	24.1	20.3	4.2	4.7	3.3	0.8	0.5	0.4
01/26/72	12.5	18.1	15.5	2.7	4.9	2.9	0.5	0.5	0.6
01/27/72	35.5	35.1	22.3	6.6	3.6	4.9	0.9	1.7	0.9
01/28/72	67.5	64.4	51.3	4.9	8.1	6.4	1.8	1.4	3.3
01/31/72	77.3	52.3	46.7	9.5	4.1	2.4	4.4	2.6	3.4
02/01/72	61.4	60.1	75.0	3.7	4.1	3.0	2.4	2.6	3.3
02/02/72	53.2	77.9	31.2	3.8	10.7	10.3	3.7	4.2	3.8
02/03/72	57.0	56.1	53.9	9.4	5.9	5.0	3.3	3.6	3.8

TABLE 8

HIGH VOLUME AIR SAMPLES EUREKA QUARTER 4

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
04/16/72	81.5	55.1	55.3	9.3	5.0	3.4	1.0	0.7	1.1
04/17/72	119.5	95.9	92.7	9.2	6.4	5.8	0.9	1.3	1.2
04/18/72	101.0	77.6	77.9	9.9	9.8	8.6	1.3	1.6	1.3
04/19/72	75.4	59.7	52.9	13.2	9.0	7.8	2.1	2.1	1.8
04/20/72	53.0	47.2	40.1	13.5	5.4	4.7	2.0	1.8	1.7
04/23/72	33.2	27.0	55.1	5.0	6.4	3.5	0.4	0.7	0.5
04/24/72	70.5	53.4	42.0	10.4	8.7	5.3	1.3	0.9	0.5
04/25/72	73.3	55.2	48.1	11.3	8.2	5.8	1.6	1.3	1.4
04/26/72	72.9	60.1	57.1	22.4	9.0	7.3	1.6	1.7	1.5
04/27/72	45.1	40.1	34.1	9.8	7.8	5.8	1.2	1.4	1.1

TABLE 9

HIGH VOLUME AIR SAMPLES   LOS ANGELES   QUARTER 2

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
12/08/71	236.3	134.1	231.0	6.7	6.5	8.9	8.0	8.8	8.4
12/09/71	141.2	105.1	151.6	5.8	3.2	5.9	5.9	7.4	7.2
12/13/71	136.3			4.5		13.0	2.7		7.4
12/14/71	125.0	94.4	116.1	6.5	7.0	7.9	8.2	8.9	10.2
12/15/71	150.4	105.6	120.5	9.3	9.0	10.3	8.9	9.2	9.5
12/16/71	235.9	202.9	127.2	7.6	7.6	8.9	11.1	12.0	12.9
12/20/71	274.3	121.9	146.6	11.2	9.9	11.2	11.2	11.7	12.0
12/21/71	124.1	113.0	137.1	9.7	10.4	9.3	12.6	13.7	15.0
12/22/71	59.8	32.4	38.5	11.2	8.9	10.6	2.1	4.3	1.5
12/23/71	92.2	77.1	89.2	9.0	6.8	9.9	5.6	8.1	7.9

TABLE 10

HIGH VOLUME AIR SAMPLES LOS ANGELES QUARTER 3

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES			SO4			NO3		
	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
03/06/72	77.2		62.7	39.5	55.4	57.4	4.1	1.4	1.0
03/07/72	103.3	85.6	82.9	24.8	37.1	42.3	6.3	3.8	4.4
03/08/72	132.2	94.5	165.5	26.0	39.9	40.6	5.8	7.3	3.8
03/09/72	124.5	100.1	123.5	15.4	20.8	13.4	7.9	7.6	5.8
03/13/72	150.1	161.7	162.2	26.4	39.4	39.3	4.2	3.4	2.1
03/14/72	225.2	200.0	199.3	39.7	44.7	63.3	4.1	1.6	1.8
03/15/72	191.4	185.5	200.6	46.4	56.3	43.8	2.9	1.1	1.6

TABLE 11

HIGH VOLUME AIR SAMPLES LOS ANGELES QUARTER 4

(CONSTITUENTS OF SAMPLE AS UG/M3)

START DATE	PARTICULATES	SO4			NO3		
		AREA I	AREA II	AREA III	AREA I	AREA II	AREA III
05/01/72		19.7	21.9	16.1	9.3	9.6	9.3
05/02/72		21.3	21.6	23.4	8.1	9.4	6.9
05/03/72		17.3	22.3	16.5	6.7	7.5	8.5
05/04/72		13.0	15.2		4.7	6.5	
05/05/72		5.3	8.8	9.3	3.3	3.6	3.2
05/09/72		13.6	13.8	4.9	5.5	8.2	4.4
05/10/72	NOT AVAILABLE	15.5	22.3	12.0	7.4	10.5	6.7
05/11/72		25.0	27.3	16.0	8.4	11.5	9.9
05/15/72		31.5	32.2	22.4	3.6	3.1	3.3
05/16/72		15.2	19.7	15.6	5.9	4.5	5.4

Table 12

RESULTS OF ANALYSIS OF VARIANCE BY RANKS FOR SUBAREAS TOTAL PARTICULATES, SO_4, NO_3

ANDERSON, EUREKA, AND CARSON

	TOTAL	QUARTER			
		I	II	III	IV
Anderson					
Total Particulates	NS	NS	NS	NS	NS
SO_4	**	NS	NS	*	*
NO_3	*	*	NS	NS	NS
Eureka					
Total Particulates	**	NS	NS	NS	**
SO_4	**	NS	NS	NS	**
NO_3	NS	NS	NS	NS	NS
Carson					
Total Particulates	*	-	*	NS	-
SO_4	NS	-	NS	NS	*
NO_3	NS		**	*	NS

* Significant at 5% level.
** Significant at 1% level.

No data available.

Note: NS represents not significant at the 5% level.

SECTION VI-I

THE MEASUREMENT OF ODOR CONCENTRATION BY DYNAMIC OLFACTOMETRY

AIHL METHOD NUMBER 25A

Scope

This method is intended for the determination of odor concentration in the atmosphere or source emissions in the ppb range in terms of a specific odorant (sp. odt.), i.e., methyl mercaptan, H_2S, etc. This is accomplished by using at least two trained and calibrated observers operating a dilution apparatus called the "Dynamic Olfactometer". (Note 1)

Principle

In this method the odor is measured at the odor threshold (O.T.) while the odorant is being introduced to a stream of deodorized air. The concentration of the odor can then be calculated from the dilution factor (D.F.) and odor threshold of the observer.

Range and Reliability

The range for ambient atmospheric sampling is from 2 to 1200 dilutions and for captured gas sampling, 2 to 300,000 dilutions.

The reliability of the olfactory measurements has been determined to be ±30%.

Interferences

Physiological conditions such as respiratory infections and allergic reactions interfere with the observer's olfactory perception. Psychological stress such as irritating noises, and elevated temperatures also affect the observer's perception.

Reagents (reagent grade)

1. Activated charcoal, 8-10 mesh.
2. Silica gel - 8-10 mesh.
3. Ethyl alcohol 95%.
4. Pyrex glass wool.

Apparatus

1. Dynamic Olfactometer (Figure 1).
    a. Pump - carbon vane pump, Gas: model 1531.
    b. Flowmeters-

       Two each with Fisher Porter designations and range of flow as follows:

        (1) #08F-1/16-08-5/36 (3-430 ml/min)
        (2) #02F-1/8-10-5/36 (7-2,100 ml/min)
        (3) #2F-1/4-20-5 (70-18,000 ml/min).
    c. Two Deodorizing Columns - 16 in. long.

       Pyrex glass tubes 1½ in. diameter.

        (1) End outlets, ₮ 45/50 joint end cap.

            Packing - 1 in. of glass wool; fill to the top of the joint with activated charcoal; fill the cap with glass wool and secure to the packed tube with springs.
        (2) Side outlets with a Teflon lid end cap.

            Packing - 1 in. of glass wool, 8 in. of activated charcoal, 1 in. of glass wool, 5 in. of silica gel; fill with wool and secure cap with a screw-type compression fitting.
    d. 300 ml surge chamber.
    e. Primary dilution chamber - modified 30 ml midget impinger.

   - f. Five outlet cyclone mixing chamber (10 in. long).
   - g. Teflon 3-way stopcock.
   - h. 4-way switching valve (S.S.).
   - i. S.S. fine metering valves (Nupro) (3 each).
   - j. S.S. course metering valves (Whitey)(4 each).
   - k. Inhalation mask - Hudson Disposable #9 Plastic oxygen mask with 4 ft. of 1/8 in. I.D. thin wall Teflon tubing.
   - l. Sampling Probe - 3/16 in. I.D., 1/4 in. O.D. Teflon tubing.

2. Assembly for Captured Sample (Figure 1).
   - a. Pressure vessel (20 liter capacity).
   - b. Tedlar Bags (See Note 2).
   - c. Pump - (capable of maintaining 10 psi press).
   - d. Metering valve - coarse (Whitey).
   - e. 2-way Teflon stopcock.
   - f. 30 psi gauge.
3. Assembly for Standardization (see Note 3).
   - a. Small gas cylinder (16 liter).
   - b. Pressure regulator.
4. Miscellaneous Tubing.
   - a. ¼ in. I.D. Tygon.
   - b. ¼ in. O.D. Pyrex glass.
   - c. ¼ in. O.D. Teflon
5. Assembly for Chemical Sampling.
   - a. Midget Impinger.

Procedure - (Refer to Figure 1)

1. Calibration of observers (odor threshold determination).

   a. Connect deodorizing column 1 to the sampling probe at I_1.

   b. Connect gas cylinder to olfactometer at inlet I_3.

   c. Set stopcock S_1 so that the total airflow will be directed through the primary dilution chamber and split with part of the air directed through deodorizing column 2 and the other part diverted to V_4.

   d. Open valves V_1, V_2 and V_6 completely. Close valves V_3, V_4 and V_5, then start the carbon vane pump.

   e. Adjust valves V_1 and V_2 to give a flow through F_6 at a rate of 12 l/min.

   f. To minimize back pressure in the system, adjust V_1 to a position that does not reduce flow below 12 l/min through F_6.

   g. Open valve V_4 completely with distributing valve S_2 open to flowmeter F_4. Adjust valve V_6 so that the readings on F_4 and F_6 are equal.

   h. Close valve V_4 and set S_2 for F_3.

   i. Turn on standard gas and regulate to 10 psi. Adjust valve V_3 to obtain a flow through F_1 sufficient to exceed the observer's O.T. when the flow through F_3 is set at midrange.

   j. Close V_4 and connect inhalation mask at O_1, place over nose and mouth of the observer, and acclimate him to the deodorized airflow.

   k. Gradually open valve V_4 until odor is perceived.

l. Record flowmeter readings on F_1, F_3 and F_6.

m. Repeat odor threshold determination two more times. Three odor threshold determinations constitute a calibration.

n. Calculation:

$$\text{O.T. as ppb of sp. odt.} = \text{ppb standard sp. odt.} \left(\frac{F_1}{F_6+F_3} \times \frac{F_3}{F_6+F_3}\right)$$

where O.T. = odor threshold

sp. odt. = specific odorant

F_1 = Flow of assayed sp. odt. through flowmeter F_1, ml/min.

F_3 = Flow of diluted sp. odt. through flowmeter F_3, ml/min.

F_6 = Flow of deodorized air through flowmeter F_6, ml/min.

The O.T. of each measurement is calculated and the average threshold determined for the observer. In practice, this is done twice daily for each observer while making odor measurements.

2. Odor concentration measurements in the ambient atmosphere.

   a. Shut off standard gas cylinder and close valve V_3.

   b. Disconnect deodorizing column at I_1 and standard gas cylinder at I_3.

c. Turn S_1 so that part of the airstream is diverted through the sampling leg.

d. Extend the sampling probe into the atmosphere and adjust valve V_2 so that the flow through F_6 is equivalent to 12 l/min.

e. Gradually open valve V_4, diverting the ambient sample through F_2, F_3, or F_4, until ambient odor is perceived.

f. Record the reading of F_2, F_3 or F_4 and F_6 at perception.

g. If no odor is perceived, the readings on F_4 and F_6 should be the same.

h. Each ambient determination constitutes a measurement.

i. Calculation:

$$D.F. = \frac{F_6 + F_n}{F_n}$$

Where F_6 = Flow of deodorized air through flowmeter F_6, ml/min.

F_n = Flow of ambient air through the appropriate flowmeter, F_2, F_3 or F_4, ml/min.

C = O.T. x D.F.

D.F. = Dilution Factor.

O.T. = Odor Threshold in terms of the calibrating odorant.

C. = Concentration of odor in terms of the calibrating odorant.

3. Captured gas analysis by olfactometry.

   a. Connect deodorizing column 1 to sampling probe at I_1.
   b. With stopcock S_3 closed, connect sample bag inside pressure vessel.
   c. For samples requiring dilutions less than 1200, connect pressure vessel to I_2 with stopcock S_1 closed.
   d. For samples requiring dilutions greater than 1200, connect pressure vessel to I_3 with stopcock S_1 open to the primary dilution chamber.
   e. Open stopcock S_3 and pressurize vessel to 7 psi.
   f. Proceed as with the ambient analysis at step 5.
   g. Calculations:
      (1) Same as ambient analysis for dilutions less than 1200.
      (2) For dilutions greater than 1200,

$$D.F. = \frac{(F_6 + F_n)}{F_1} \times \frac{(F_6 + F_n)}{F_n}$$

where D.F. = Dilution Factor.

F_6 = Flow of deodorized air through flowmeter F_6, ml/min.

F_1 = Flow of sample air through flowmeter F_1, ml/min.

F_n = Flow of diluted sample air through the appropriate flowmeter, F_2, F_3 or F_4, ml/min.

4. Captured gas chemical analysis.

   a. Use the same system as for olfactometry analysis with the sample connection at I_2.

   b. Connect midget impinger at O_2.

   c. Adjust to desired flow rate on F_2, F_3 or F_4 and F_5 and F_6.

   d. Calculations:

$$\text{D.F.} = \frac{(F_6 + F_n)}{F_n} \times \frac{(F_6 + F_n)}{F_5}$$

Where D.F. = Dilution Factor.

F_6 = Flow of deodorized air through flowmeter F_6, ml/min.

F_n = Flow of sample air through the appropriate flowmeter, F_2, F_3 or F_4, ml/min.

F_5 = Flow of diluted sample air through flowmeter F_5, ml/min.

$$C = \text{D.F.} \times \frac{X}{V}$$

where C = Concentration in captured gas sample, μl/l.

X = μl of gaseous compound being analyzed in impinger.

V = Volume of diluted sample air collected, liters or,

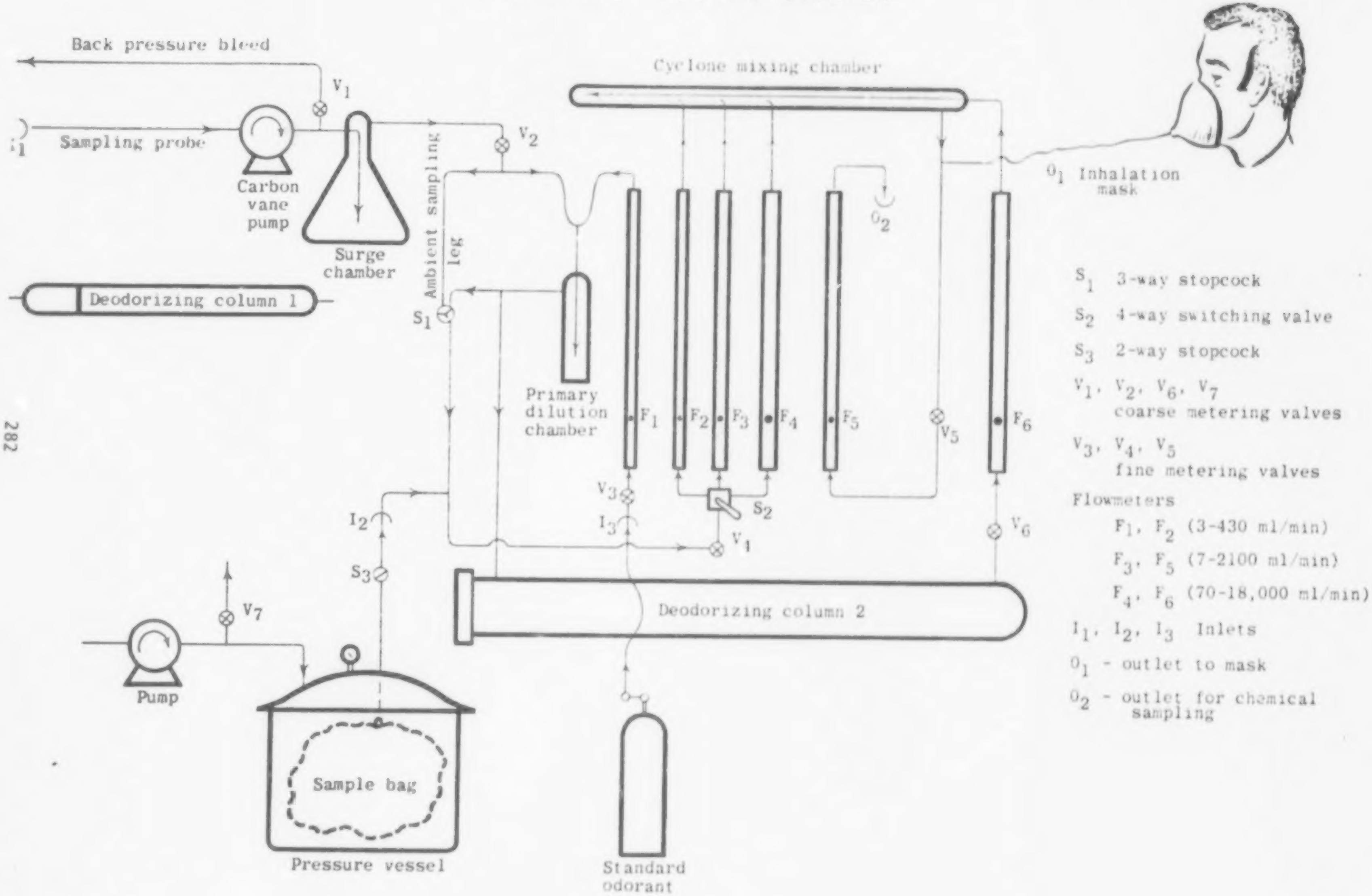
$$\frac{(F_5\text{, ml/min x time sampled, min.})}{1000 \text{ ml/l}}$$

Notes

1. Selection of Observers:
    a. Observers' odor thresholds should agree within ± 1 ppb.
    b. Observers should perceive the odor with the same psychological response, i.e., pulp mill odor is disagreeable.
2. The materials used for sample bags are evaluated in AIHL Reports # 73 and 80.
3. Preparation of standard gas - The odorant is placed in an evacuated cylinder, diluted and pressurized to 500 lbs/in^2 with nitrogen. Assay by an appropriate procedure (i.e., for methyl mercaptan, see (AIHL recommended method 23).

FIGURE 1

DYNAMIC OLFACTOMETER


Back pressure bleed
V_1
I_1
Sampling probe
Carbon vane pump
Surge chamber
V_2
Ambient sampling leg
S_1
Deodorizing column 1
Primary dilution chamber
Cyclone mixing chamber
F_1
F_2
F_3
F_4
F_5
F_6
O_2
V_5
O_1 Inhalation mask
V_3
I_3
S_2
V_4
V_6
I_2
S_3
V_7
Pump
Deodorizing column 2
Sample bag
Pressure vessel
Standard odorant
S_1 3-way stopcock
S_2 4-way switching valve
S_3 2-way stopcock
V_1, V_2, V_6, V_7 coarse metering valves
V_3, V_4, V_5 fine metering valves
Flowmeters
F_1, F_2 (3-430 ml/min)
F_3, F_5 (7-2100 ml/min)
F_4, F_6 (70-18,000 ml/min)
I_1, I_2, I_3 Inlets
O_1 - outlet to mask
O_2 - outlet for chemical sampling

THE MEASUREMENT OF MALODOR IN A COMMUNITY BY DYNAMIC OLFACTOMETRY*

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INTRODUCTION

Methods which have been used to evaluate malodor in air pollution problems have been previously reviewed (1). Various aspects of static and dynamic olfactometry have partly been discussed by Lindvall (2). Nader (3) described an interesting arrangement for dynamically determining malodor concentrations in the atmosphere on the basis of dilution measurements.

To evaluate a specific malodor problem arising from the emission of organic sulfur gases from kraft pulp mills, an analogous dynamic olfactometer was developed and described by one of us independently (4). The purpose of this paper is to describe our method, its reliability, and its application to measure the frequency of occurrence and concentration of malodor in different areas of a community (5,6).

DYNAMIC OLFACTOMETRY

A mobile system has been devised by which the concentration of malodor can be measured directly in the ambient air or in a captured sample from a point source. The ambient odor concentrations were determined by dynamic olfactometry for which the details are described in Recommended Method No. [illegible]-A.

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*Presented at the Conference on "Methods for Measuring and Evaluating Odorous Air Pollutants at the Source and in the Ambient Air" Stockholm, June 1-5, 1970.

The concentration of the malodor is quantitatively expressed with reference to a known concentration of the major gas in the malodor, by a group of observers whose odor thresholds have been calibrated for this gas. Methyl mercaptan (CH_3SH) was used as the calibrating gas for the observers because it was a major constituent of the malodor emissions, and it also has the lowest median odor threshold (0.8 ppb) (7) in the mixture of malodor gases being emitted.

The system is so arranged that an individual breathing a stream of deodorized air at constant rate is challenged with the introduction of a stream of malodorous air into the odorless air until the malodor is perceived. The ratio of the rate of the malodor air to the rate of odorless air is the *dilution factor* (D.F.), which is a function of the odor concentration in the malodor stream. The *concentration of malodor* (C), is expressed in ppb as CH_3SH. This is the product of the dilution factor and the observer's *odor threshold* (O.T.), as described in the procedure contained in the appendix. (Recommended Method 25-A)

The olfactometer was placed into a large station wagon for mobility. The observer was isolated from the environment by keeping the vehicle window closed. The sampling probe was a Teflon tube protruding from the vehicle six inches above the roof, upwind from the tail pipe. Characteristic car exhaust gas odors were never detected.

RELIABILITY

The reliability of malodor concentrations is a function of the variations in odor thresholds of individual panel members and in the determination of dilution factors. The lowest detectable odor concentration is the odor threshold of the most sensitive observer, 0.3 ppb CH_3SH in this study.

Each observer's odor threshold (O.T.) was determined each morning and afternoon from three successive one minute tests on a known concentration of CH_3SH. The average of the three tests constituted a calibration. The variation within these calibrations was utilized to obtain an estimate of the reliability of our procedure.

Using each calibration we calculated for each individual and a composite of all observers the mean odor threshold, the median coefficient of variation of the calibrations and the 95% confidence intervals about the mean odor threshold. These values are given in Table I. The number of calibrations differed from observer to observer and each observer made about 22 field tests for each calibration. Thus, observers number I and II made about 75% of all the field tests.

The mean odor threshold varied from 0.68 for observer number III to 1.14 ppb CH_3SH for observer number I. The median coefficient of variation ranged from 11.47% for observer number I to 28.70% for observer number IV. However, the overall median coefficient was 13.34% and was not affected substantially by observer number IV.

The 95% confidence intervals ranged from 13.3% of the mean O.T. for observer number I to 43.0% for observer number IV. For all the study periods and all observers the 95% confidence interval was 26.8% to 20.8% for all observers without observer number IV. Both observers number I and III were smokers. They did not smoke within 30 minutes prior to making a test. Observer number IV experienced nasal congestion part of the time, but expediency precluded eliminating his participation.

The results of a two-way analysis of variance using time of day (a.m. vs p.m.) and date for each individual are shown in Table II. Only one observer (number II) showed no significant time of day or date differences. The other three observers showed significant interactions, that is, time of day differences were not constant over all days.

One observer showed time of day differences, one showed date differences, and one showed both. The significance of date differences is compensated for by the use of separately determined odor thresholds for each day. The time of day differences are partly compensated for by use of separate morning and afternoon odor threshold determinations.

Having determined the reliability of the O.T. determination per se a question remains concerning the transfer of this information to estimate the determination of malodor concentration (C) in the community. This is calculated by:

$$C = O.T. \times D.F. \qquad (1)$$

where D.F. is the dilution factor. In the calibration tests to determine O.T., the dilution factors ranged from 10 to 200. In the test to determine community malodor, D.F. varied within the same range. Therefore, it seems reasonable to assume that the same percentage range of variability present in the O.T. determination would also be present in the D.F. measurement. Rewriting equation (1) we can express this as:

$$C \pm (e \times C) = (O.T. \pm K \times O.T.) \times (D.F. \pm K \times D.F.) \qquad (2)$$

where K is 26.8%, the percentage of O.T. and D.F. calculated from the range of the 95% confidence interval. While we have not yet rigorously solved for e in equation 2, we have estimated the measured malodor concentrations to be within ± 50% with at least 90% confidence $[(95\%)^2]$. The more rigorous estimate of the variability of D.F. and resulting concentration, could be obtained by panel members with similar O.T.s making tests simultaneously on the same ambient air samples.

STUDY DESIGN

The study took place in a Northern California coastal city with a population of 30,000. The sources of the malodor were two pulp mills located on a peninsula west of the city on the ocean side. The prevailing wind pattern from April to November is northwest. The average wind velocity is 12-15 mph between 11 a.m. and 7 p.m. During the rest of the 24 hour period it is less than 5 mph.

To characterize the malodor pattern for the community, three areas were chosen within the community to represent high (Area I), medium (Area II), and low (Area III) malodor exposure. The locations of the three areas with respect to the sources of malodor are shown on the map (Figure 1). They were approximately equal in socioeconomic status to avoid bias.

Malodor tests were made on a total of 24 days during three months (June, July and August 1966) while the prevailing wind pattern was from the northwest. Each month tests were conducted on eight days, in two consecutive weeks from Monday noon to Friday noon spanning the daylight hours 0800 to 1700. The areas were sampled in intervals begun on the hour and half hour. Malodor tests required approximately one minute each with sampling of the area complete in 15 minutes. Traveling time between areas was 10 minutes.

A malodor panel of six trained observers was chosen, four regular observers and two for relief. The regulars were calibrated with CH_3SH before and after each day's sampling. The relievers were calibrated at their time of participation -- a total of 16 calibrations. (Because of their limited participation these calibrations were excluded from the previous analysis of reliability of O.T. determinations.) The malodor tests at each sampling site were made by each of two observers. The observer's morning O.T. was used to calculate the morning malodor concentrations, while the afternoon concentrations were based on the afternoon O.T.

To obtain a representative sampling of each area, a primary sampling site, and alternating secondary sites were selected. This was done to obviate assuming that a single site would be representative of an area. Areas I and II had three secondary sites, while Area II had two secondary sites because of its smaller size.

In each sampling interval, Area I was sampled four times, Area II six times and Area III eight times. The greater number of tests in Areas II and III were chosen in order to detect the expected lower frequencies of malodor occurrence.

In Area I the two observers made one test each at the primary and secondary sites, while in Area III each observer made two tests at each of the two sites. In Area II the sequence was a little more complex. At the primary site, observer one made two tests and observer two made one test in the first sampling interval. Then, at the secondary site observer one made one test and observer two made two tests. In successive sampling intervals the test sequence roles of the two observers were interchanged.

The distribution of the number of tests in each area is shown by site and by morning and afternoon in Table III. A total of 2,538 tests were made. One half of the total number of measurements in each area were made at the primary site. The remaining number of measurements in each were divided almost equally between the secondary sites. This gradation of the number of measurements in the respective areas was designed to account for the dilution of malodor due to increasing distance from the point sources. The design of the sampling protocol did not take into detailed consideration dispersion factors influenced by meteorology and topography. The primary site was also used for obtaining two hour chemical measurements for total mercaptans and hydrogen sulfide. But these measurements turned out to be unsuitable for comparison with the malodor tests.

MALODOR FREQUENCY

The distribution of malodor frequencies for the entire study period is given by area, site within each area for morning and afternoon and the entire day in Table IV. The data in this table establishes very clearly malodor frequencies in Areas I through III decrease from high to low thereby validating the study protocol. Generally, the range of malodor frequencies among sites within each area did not overlap among the three areas.

From the results obtained at each site in Area I, it can be seen that secondary sites 2 and 3 experienced about 40% greater malodor frequency than the designated primary site. It should be noted that site 2 was one block south of the primary site and was centered in Area I. Sites 0 and 1 were situated on the edge of the populated area at a slightly lower elevation than either sites 2 or 3.

Since sites 2 and 3 were slightly higher in elevation and denser in population than sites 0 and 1, the higher malodor frequency at sites 2 and 3 could be explained by the following:

a. Higher elevation, when sufficiently close to the source, such as was Area I, allows the high altitude emissions to contact the ground with greater frequency.

b. In areas of dense population, where airflow is restricted due to existing structures, malodor tends to linger allowing the same malodor to be detected over an extended period of time.

Area II shows a more uniform distribution of malodor frequency with respect to both time of day and sampling site. The entire Area II was a typical residential area of moderate population and was situated on level ground. The three sampling sites in Area II were physically alike in most ways, which explained their rather uniform malodor frequency.

In Area III the secondary sites had a somewhat greater malodor frequency than the primary site. The primary site was situated in a school parking lot with unobstructed areas adjacent to two sides of it allowing free air circulation. Sites 2 and 3 were in areas of relatively moderate population density which tends to restrict airflow, thus allowing malodors to linger. Site 1 was peculiar in that while being on the same level as the other sites, it had a low population density and was situated on the edge of a large field containing grass, weeds and shrubs. We found that in this case, as the sun came through the fog and vaporized the dew on the vegetation, we perceived more malodors, thus giving us a high malodor frequency.

The afternoon malodor frequency for Area I was twice that of the morning. This was due to the wind increasing and changing direction late in the morning and carrying the malodor inland over Area I and the rest of the community. (See map (Figure 1) for prevailing afternoon wind patterns.) Area III showed a pattern of malodor frequency analogous to Area I with respect to morning and afternoon.

The diurnal changes in malodor frequency are given in Table V for each of the three areas. This data is presented graphically in Figure 2. In Area I there was a higher frequency of malodor occurrence in the afternoon. However, the change in malodor frequency from one sampling interval to another after 1300 was considerably greater than the changes observed before 1300. Similarily in Areas II and III the changes between adjacent sampling intervals increased considerably after 1400. For all three areas there was a relatively uniform malodor frequency between the hours of 1000 and 1300. The nature of these fluctuations in malodor frequency during the day are consistent with the meteorological observation that atmospheric instability increased in this area after 1400. During periods of decreased stability malodor from the plume is more likely to reach ground level by convection. These diurnal variations in air motion lead to expectations of some fairly wide fluctuations in malodor concentration in the afternoon.

MALODOR CONCENTRATION

The range of malodor concentrations observed during the study, is given in Table VI by area and by time of day. In Area I the maximum concentrations ranged from about 6 to 250 ppm CH_3SH. In Area II the maximum concentrations ranged during the day from essentially 0 to 171 ppb. In Area III the maximum concentrations ranged from essentially 0 for almost half the sampling intervals to 23 ppb CH_3SH late in the afternoon. Thus, there was a substantial difference in the maximum malodor concentrations experiencel in the three areas. In accordance with the odor frequency patterns the largest fluctuations in concentrations were observed in all areas in the afternoon.

The malodor concentrations below which a certain proportion of the observed measurements occurred are given in Table VII by time of day and by area. The 75th and 92nd percentiles are given for Area I. Only the 92nd percentiles are given for Areas II and III because, as was shown in Table V, the malodor frequency was generally less than 25% in Areas II and III. The 92nd percentile happens to be the median point of the overall malodor frequency (15.6%) observed for all areas and sampling intervals during this study. The 92nd percentile columns show the concentrations which were exceeded 8% of the time. Consistent with the maximum malodor concentration pattern, the 92nd percentile columns show a range of concentration which was greatest for Area I, intermediate for Area II and lowest for Area III.

These diurnal concentration fluctuations show an overall pattern graphically illustrated in Figure 3. Figure 4 shows the expected diurnal malodor patterns in terms of relative concentrations based on casual observations and malodor complaints received by the local health department during the summer season in recent years. Figure 3 shows that the observed patterns coincide with the expected for Areas I and III. However, the observed patterns for Area II are quite different from that expected. This discrepancy demonstrates the importance for systematically and objectively evaluating malodor occurrences in a community. However, the diurnal malodor concentration pattern for all three areas combined (Figure 5) again resembles a composite of the expected diurnal malodor patterns.

From these measurements we have shown that subjective responses by individuals in a community are adequate indicators of the overall extent of a malodor problem. The importance of systematic and objective studies is to determine the degree of control necessary at the source to reduce the malodor to an acceptable level in the community. The acceptable levels depend on attitudes in the community and can be determined by an objective community reaction study. Such a study was conducted simultaneously in Areas I, II and III during August of 1969 and is to be reported by Dr. Erland Jonsson and co-workers (5).

SUMMARY AND CONCLUSION

A method has been developed to measure the concentration and occurrence of malodors in a community. The measurements are made by a panel of trained observers utilizing a portable dynamic olfactometer. We have shown a malodor concentration test by a single observer to be reliable within ± 50%.

This method has been applied to study objectively a malodor problem created by emissions from kraft pulp mills. The measurements were made in areas where the malodors occur thereby exposing the observers to environmental conditions experienced by the people in the community. Diurnal differences in areas of the community at different distances downwind from the sources are described. In line with expectations the areas furthest from the sources had the lowest malodor concentrations and the least number of malodor occurrences. By the use of this method we were able to demonstrate a diurnal pattern for each area and an overall pattern which was indicative of experience in the community.

The ability to systematically and objectively obtain information on malodor has been established. It is now possible to make decisions concerning acceptable levels and to establish the degree of control needed at the source to attain such levels.

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TABLE I

MEASUREMENTS OF VARIABILITY IN ODOR THRESHOLD

Observer	Mean O.T. ppb CH_3SH	Number of Calibrations	Median Coeff. of Variation %	95% Confidence Interval for Mean Odor Threshold Range (ppb)	±% of Mean (K)
I	1.14	25	11.47	0.99-1.29	13.3
II	0.86	51	13.34	0.66-1.06	23.4
III	0.68	9	15.51	0.45-0.91	33.4
IV	1.01	18	28.70	0.57-1.44	43.0
Overall Less KC	0.92	85	12.39	0.73-1.11	20.8
Overall	0.94	103	13.34	0.69-1.19	26.8

TABLE II

RESULTS OF ANALYSIS OF VARIANCE
F-Ratios for Each Observer

	Observer			
Test	I	II	III	IV
Date Difference	27.00*	0.46	1.25	7.70*
A.M.-P.M. Difference	0.50	0.34	5.50*	12.87*
Interaction	4.00*	0.17	9.25*	2.71*

*Significant at the 5% level

TABLE III

NUMBER OF MALODOR TESTS
By Area, Site*, and Time of Day

Time	Site	Area I	Area II	Area III	All Areas
0800 to 1159	All sites	256	384	512	1152
	0	140	210	280	630
	1	42	72	88	202
	2	44	102	72	218
	3	30	---	72	102
1200 to 1659	All sites	308	462	616	1386
	0	168	252	332	752
	1	40	123	84	247
	2	44	87	100	231
	3	56	---	100	156
0800 to 1659	All sites	564	846	1128	2538
	0	308	462	612	1382
	1	82	195	172	449
	2	88	189	172	449
	3	86	---	172	258

* Site 0 Primary sampling site
1 First secondary sampling site
2 Second secondary sampling site
3 Third secondary sampling site

--- No malodor tests conducted

TABLE IV

MALODOR FREQUENCY*
By Area, Site**, and Time of Day

Time	Site	Area I	Area II	Area III	All Areas
		%	%	%	%
0800 to 1159	All sites	23.4	13.5	3.5	11.3
	0	23.6	12.4	2.1	10.3
	1	9.5	13.9	3.4	8.4
	2	29.5	15.7	6.9	15.6
	3	33.3	---	5.6	13.7
1200 to 1659	All sites	49.0	14.5	8.0	19.3
	0	42.9	16.3	6.0	17.7
	1	50.0	12.2	14.3	19.0
	2	65.9	12.6	6.0	19.9
	3	53.6	---	11.0	26.3
0800 to 1659	All sites	37.4	14.1	5.9	15.6
	0	34.1	14.5	4.2	14.3
	1	29.3	12.8	8.7	14.3
	2	47.7	14.3	6.4	17.8
	3	46.5	---	8.7	21.3

* Number of malodor detections as a percent of total odor tests

** Site 0 Primary sampling site
1 First secondary sampling site
2 Second secondary sampling site
3 Third secondary sampling site

--- No malodor tests conducted

TABLE V

DIURNAL MALODOR FREQUENCY*
BY AREA AND TIME

Sampling Interval Begun At	Area I %	Area II %	Area III %
0800	15.6	2.1	0.0
0830	12.5	6.3	4.7
0900	12.5	27.1	0.0
0930	25.0	10.4	0.0
1000	37.5	0.0	0.0
1030	21.9	12.5	6.3
1100	31.3	27.1	9.4
1130	31.3	22.9	7.8
1200	15.6	18.8	7.8
1230	37.5	14.3	6.3
1300	28.6	22.9	9.4
1330	71.9	18.8	3.6
1400	37.5	23.8	0.0
1430	78.6	2.1	28.2
1500	56.3	22.9	1.8
1530	43.8	2.4	0.0
1600	57.2	0.0	20.3
1630	65.7	18.8	0.0

*Number of malodor detections as a percent of total odor tests.

TABLE VI

MAXIMUM MALODOR CONCENTRATION DETECTED*
BY AREA AND TIME
(as ppb CH_3SH)

Sampling Interval Begun At	Area I	Area II	Area III
0800	8.9	4.4	N.D.
0830	12.9	2.4	5.1
0900	11.4	28.2	N.D.
0930	52.5	3.8	N.D.
1000	59.2	N.D.	N.D.
1030	6.4	38.9	3.2
1100	24.7	5.5	2.4
1130	5.6	16.5	5.6
1200	10.1	31.2	1.4
1230	38.6	2.9	6.0
1300	33.3	5.0	7.1
1330	19.7	170.7	1.4
1400	28.1	23.9	N.D.
1430	249.6	0.9	21.9
1500	47.1	12.6	1.6
1530	16.6	1.2	N.D.
1600	26.0	N.D.	23.1
1630	239.4	16.1	N.D.

*In each case the concentration ranged from none detected to the maximum shown.

N.D. - none detected which means less than 2 x minimum O.T. of the observer - essentially 0.

TABLE VII

DIURNAL MALODOR CONCENTRATION AT GIVEN PERCENTILES BY AREA AND TIME

(as ppb CH_3SH)

Sampling Interval Begun At	Area I		Area II	Area III	All Areas
	75th	92nd	92nd	92nd	92nd Percentile
0800	N.D.	5.8	N.D.	N.D.	N.D.
0830	N.D.	5.8	N.D.	N.D.	N.D.
0900	N.D.	2.9	12.7	N.D.	3.2
0930	N.D.	5.5	1.4	N.D.	1.9
1000	1.9	4.4	N.D.	N.D.	1.5
1030	N.D.	2.4	17.1	N.D.	1.9
1100	2.5	12.1	3.5	1.6	3.9
1130	1.3	3.3	8.1	1.9	4.9
1200	N.D.	4.0	2.3	0.5	2.1
1230	2.6	15.8	1.9	N.D.	3.1
1300	1.8	5.5	2.5	1.8	2.8
1330	9.2	17.2	7.0	N.D.	10.4
1400	2.6	11.4	2.2	N.D.	2.7
1430	9.2	30.3	N.D.	5.6	9.2
1500	5.7	14.3	5.6	N.D.	7.1
1530	4.4	8.7	N.D.	N.D.	2.9
1600	7.7	9.6	N.D.	5.6	7.7
1630	7.0	12.3	3.9	N.D.	7.0

N.D. - none detected, essentially 0.

Figure 1

MALODOR STUDY LOCATION MAP

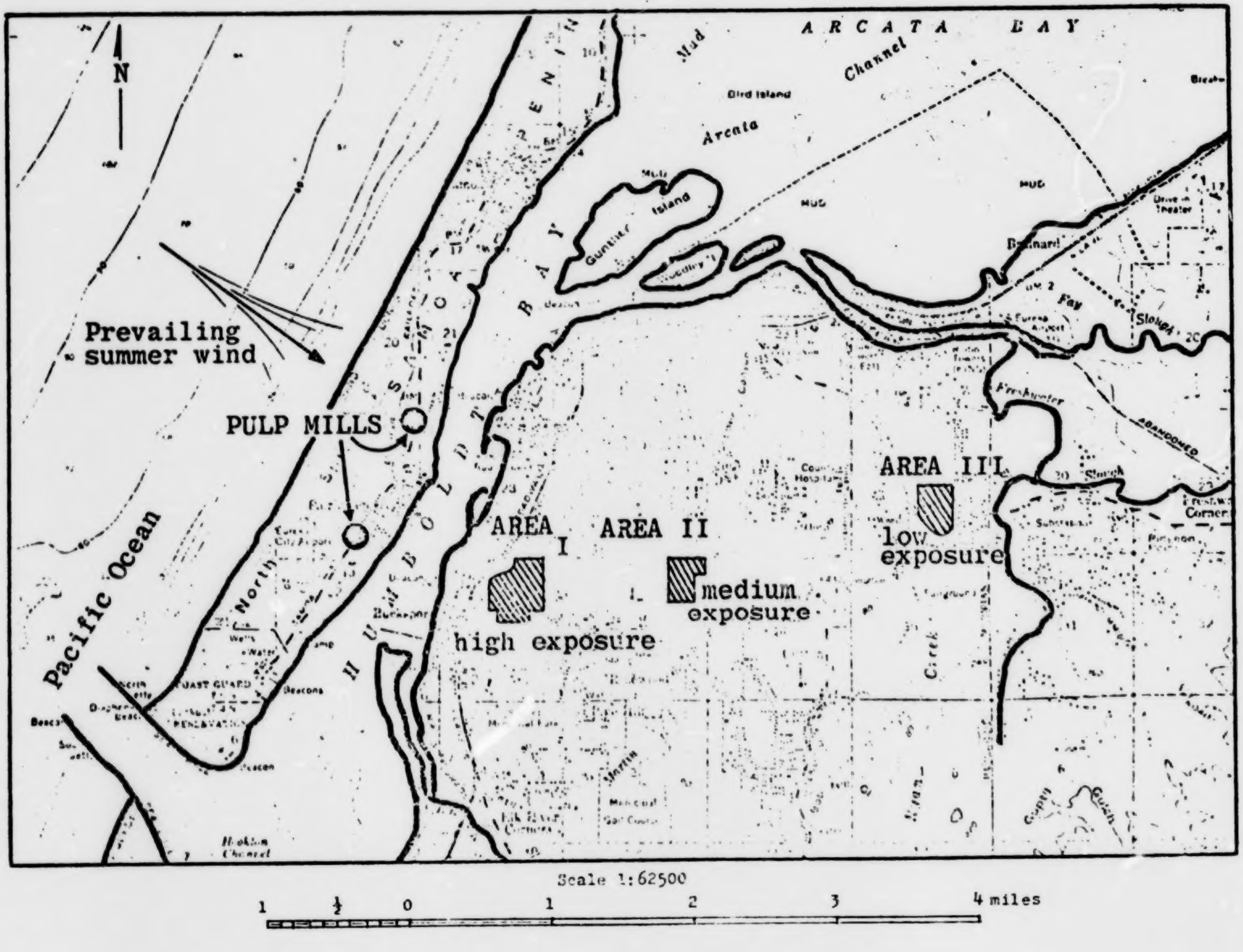

N
ARCATA BAY
Mad
Channel
Bird Island
Arcata
Gunther Island
Prevailing summer wind
PULP MILLS
Pacific Ocean
North
COAST GUARD
Beacons
SAMOA
HUMBOLDT BAY
AREA I
high exposure
AREA II
medium exposure
AREA III
low exposure
Freshwater
Slough
Fay
Creek
Gulch
Scale 1:62500
1
½
0
1
2
3
4 miles

Figure 2

DIURNAL MALODOR FREQUENCY BY AREA

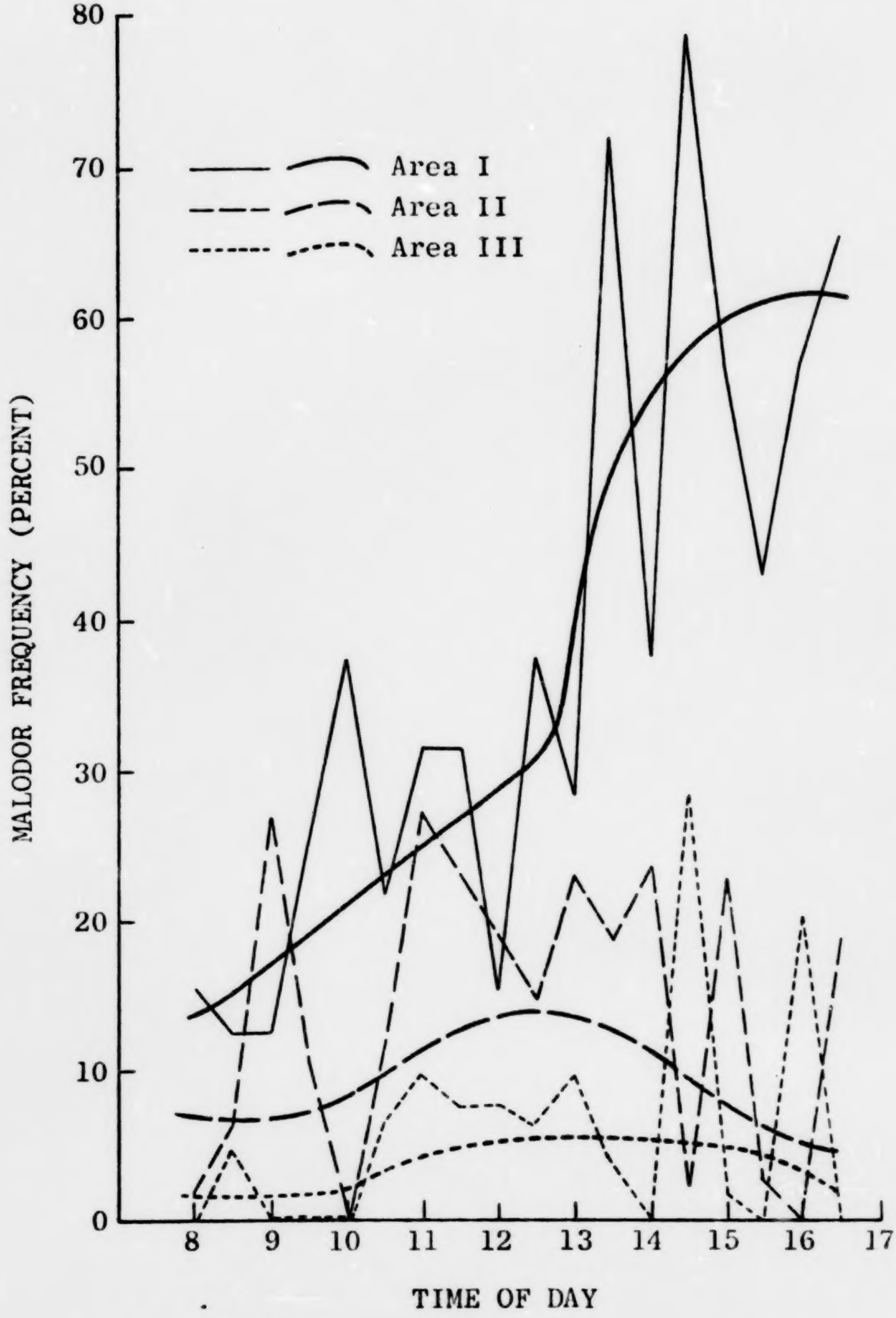


Figure 3
OBSERVED DIURNAL MALODOR PATTERN BY AREA

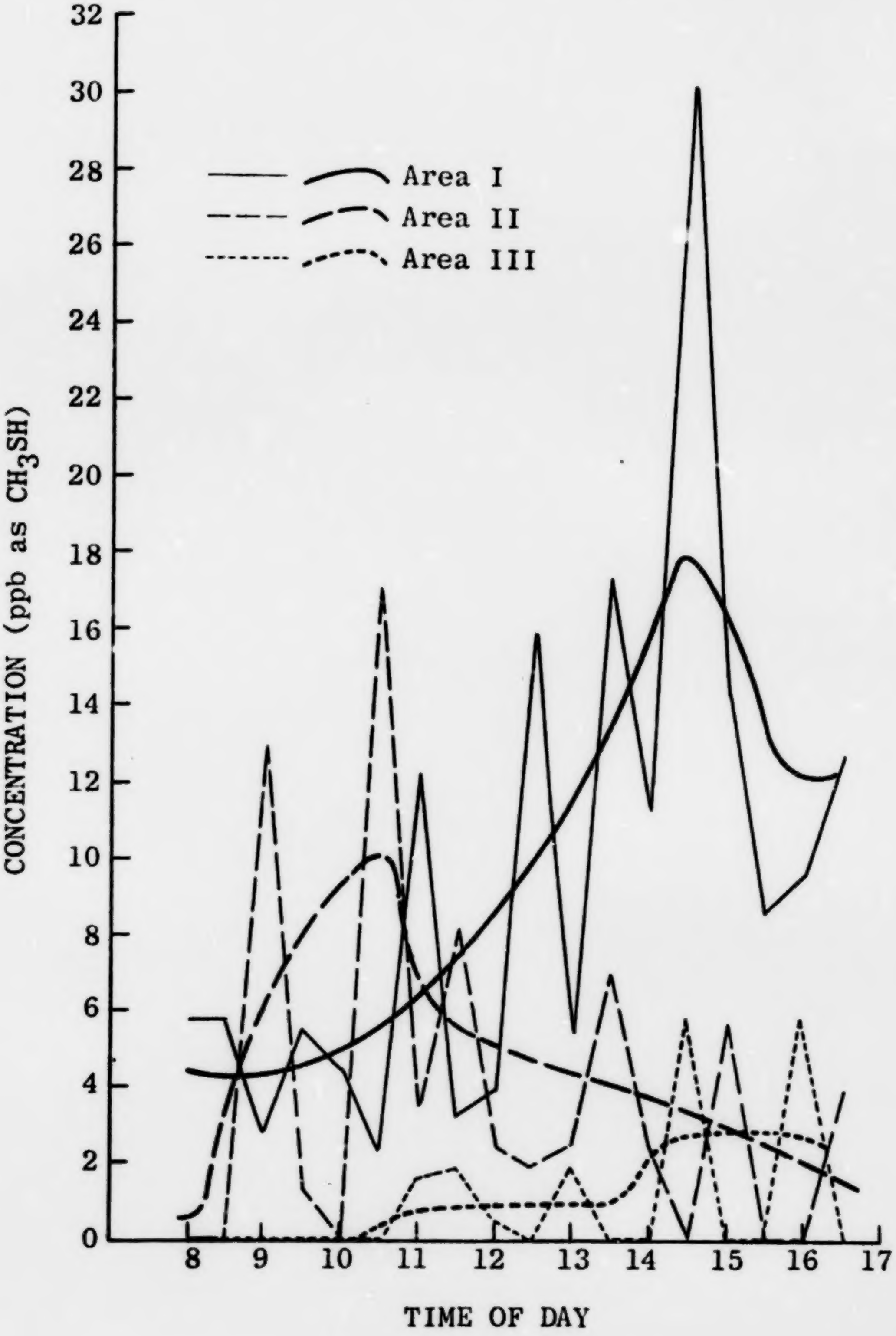


Figure 4

EXPECTED DIURNAL MALODOR PATTERN

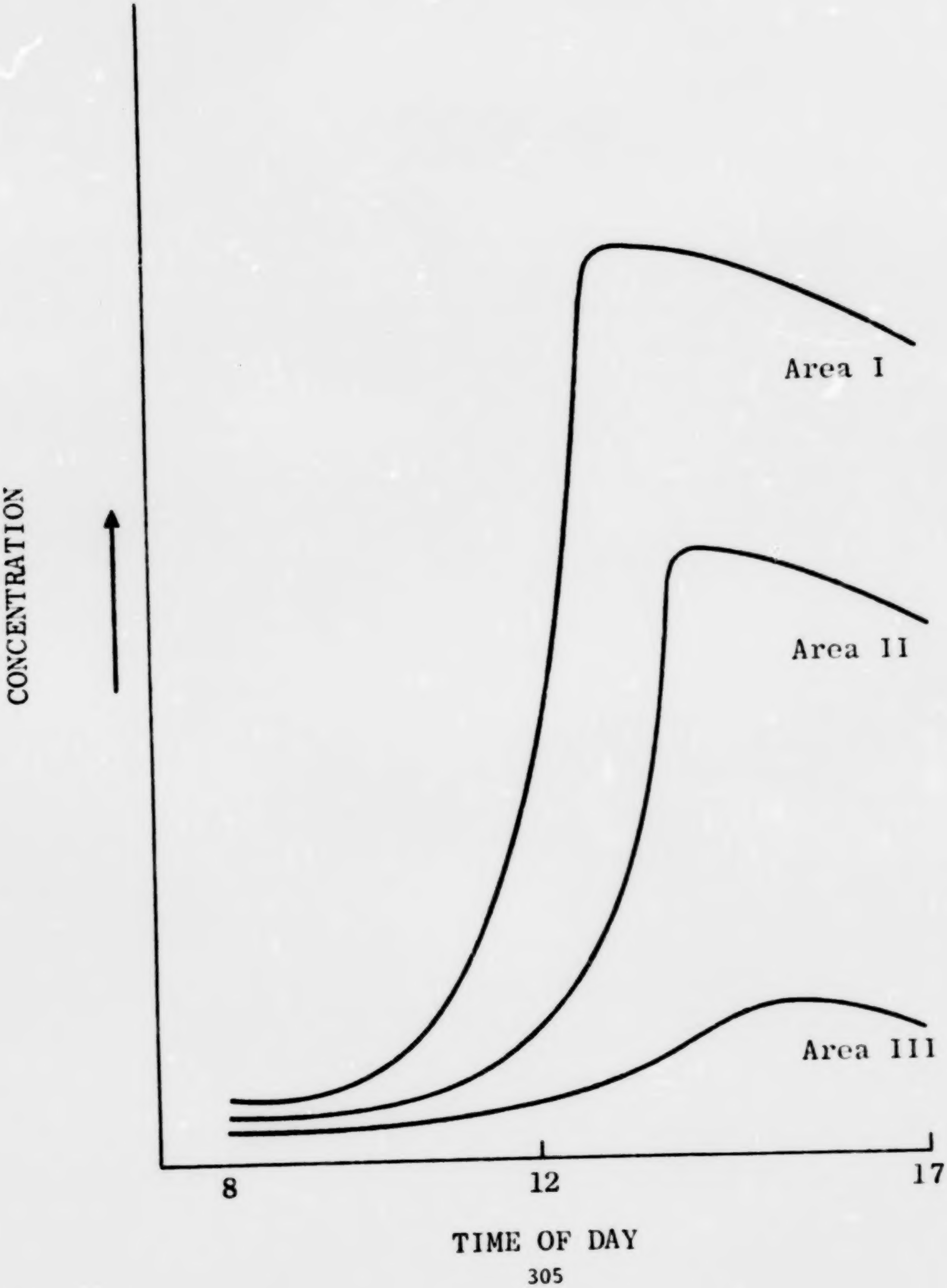
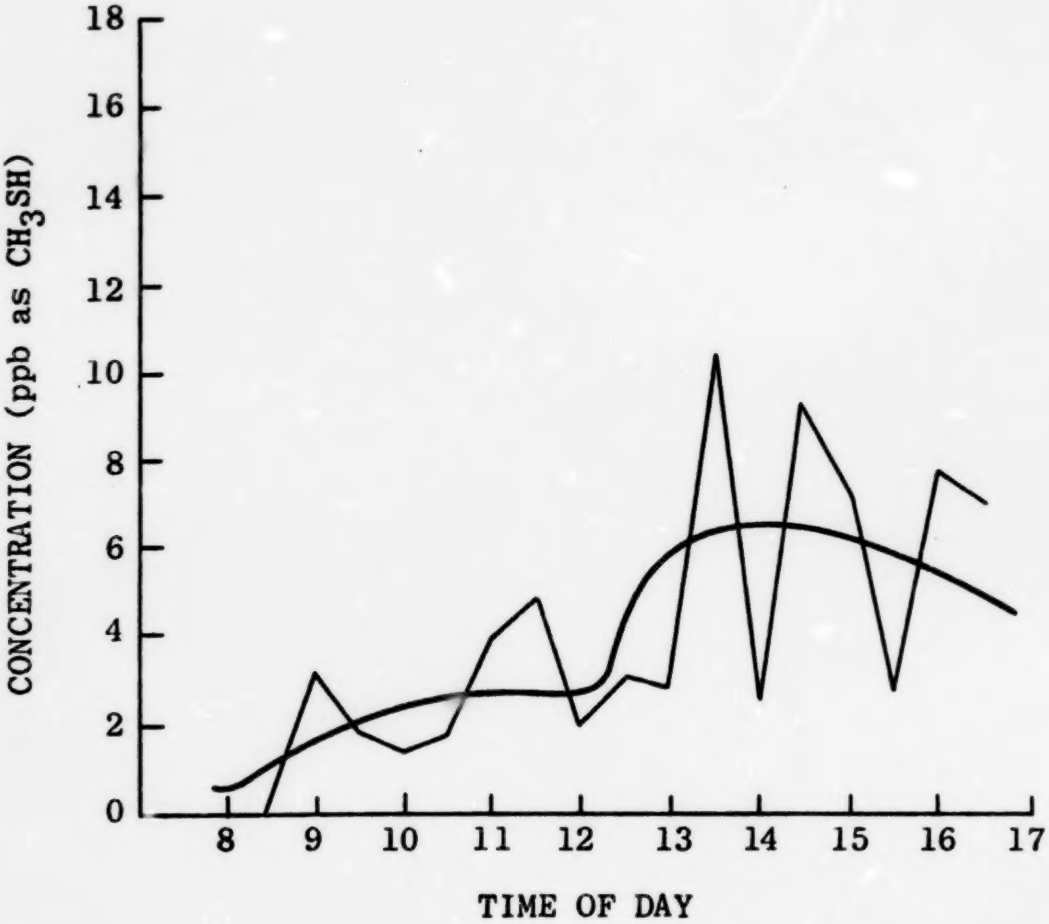


Figure 5

OBSERVED DIURNAL MALODOR PATTERN FOR ALL AREAS



SECTION VII-A

EUREKA-1969

(Annoyance Reactions)

I.D._______________ Date_______________

Interviewer____________________

Introduction

I'm____________________________from the State Human Relations Agency. We are making a survey on how people feel about the community in which they live. I would like to ask you some questions about where you live and work.

Address____

____

Census Table

						Education			
Household Member	Age	Sex	Marital Status	Occupation	Work Place	E.S.	H.S.	C.E.	B.A.
I. P.						1	2	3	4
Spouse	--	--				1	2	3	4
Child 1		--				1	2	3	4
Child 2		--				1	2	3	4
Child 3		--				1	2	3	4
Child 4		--				1	2	3	4
Child 5		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4

Ask marital status, occupation, work place, and education only for adults and for children at least 17 years old.

Respondent

61 Sex 1 M. 2 F. 62 Age 1 2 3 4

Marital 63 1 NM 2 M 3 W 4 D/S

	Husband					Wife				
Occupation	64	1 B.C.	2 W.C.	3 P.		65	1 B.C.	2 W.C.	3 P.	
Mill	66	1 Yes	2 No			67	1 Yes	2 No		
Location	68	1	2	3	4	69	1	2	3	4
Education	70	1 E.S.	2 H.S.	3 C.E.	4 B.A.	71	1 E.S.	2 H.S.	3 C.E.	4 B.A.

Household Size										
Total No.	72	1	2	3	4	5	6	7	8	9+
No. of Children less than 6	73	1	2	3	4	5	6	7	8	9+
6-16	74	1	2	3	4	5	6	7	8	9+
Adults	75	1	2	3	4	5	6	7	8	9+

Card No. 1

1. Ask only if not obvious (check type of dwelling unit).

Do you live in:

1 a single house

2 a row house (town house)

3 an apartment house with less than 5 apartments

4 an apartment house with more than 5 apartments

5 trailer?

6 other ______________________

2. How many rooms are there in your home? __________

How many bedrooms are there in your home? __________

Does this include all the rooms used
regularly for sleeping? __________

1

2 [Number of married couples plus number of single people ________]

3 (From table on p. 1)

4 [Determine code from table.]

5

3. What hours during the week days are you usually in your home?

1 Codes: Between 8:00 A.M. - 8:00 P.M.

2 between ____ - ____ 1 ≤ 3 hours

3 and between ____ - ____ 2 4 - 6

4 If "other", such as traveler, 3 7 - 9
working alternate shifts,
5 explain here __________ 4 10 - 12

5 other

Card No. 1

4.			How long a time have you lived in Eureka? ________
			How long a time have you lived in this residential area? ________
		1	How long a time have you lived in this house? Years ________ 1 Same house before pulp mills came
		2	2 Same residential area but different house
		3	3 Eureka but different residential area
		4	4 Moved into residential area after pulp mills came
5.			In general, how do you feel about living in this residential area? Do you rate it as ~~an~~:
		1	good
		2	fair
	8	3	poor?
	8	0	D.K. (Don't know)
6.			What are some of the things you like about living around here - things that you feel are advantages or that make this a good place to live? ________ ________
7.			Nowadays, it is seldom that a residential area has advantages only. What about the things you don't like here? Would you say there is:
	9	1	nothing at all you don't like
		2	a few things or
		3	many things?
	9	0	D.K.

Card No. 1

8.			**What are some of the things you don't like about living here?**
		1	odor from pulp mills
		2	odor from pulp mills and air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of pulp mills)
		4	other (without mention of any of the above)
			________________________
9.			Have you ever felt like moving away from this residential area?
		1	Yes
	13	2	No
	13	0	D.K.
10.			When you have felt like moving away, what has the reason been?
		1	odor from pulp mills
		2	odor from pulp mills and air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of pulp mills)
		4	other (without mention of any of the above)
			________________________
11.			If you could find a similar apartment (house) which would not be more expensive in another residential area, would you like to move there?
		1	Yes
	13	2	No
	13	0	D.K.
12.			Why would you like to do this?
		1	odor from pulp mills
		2	odor from pulp mills and air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of pulp mills)
		4	Other (without mention of any of the above)
			________________________

Card No. 1

13.			**Is there anything here in the community that you think is harmful for you or your family?**
		1	**Yes**
	15	2	**No**
	15	0	D.K.
14.			What is this?
		1	odor from pulp mills
		2	odor from pulp mills and air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of pulp mills)
		4	other (without mention of any of the above)
			______________________________
15.			Here are a few problems which different communities are facing. How would you rate each of these for Eureka today in terms of serious, somewhat serious, or not serious?
			Outbreaks of contagious diseases, such as whooping cough, diphtheria, etc.
		1	serious
		2	somewhat serious
	17	3	not serious
	17	0	D.K.
16.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?______________________________
		2	No.
		0	D.K.

Card No. 1

17.			**Water pollution**
		1	serious
		2	somewhat serious
	19	3	not serious
	19	0	D.K.
18.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?________________________
		2	No
		0	D.K.
19.			Noise in the community or residential area.
		1	serious
		2	somewhat serious
	21	3	not serious
	21	0	D.K.
20.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?________________________
		2	No.
		0	D.K.
21.			Air pollution.
		1	serious
		2	somewhat serious
	24	3	not serious
	24	0	D.K.
22.			What kind of air pollution are you thinking of?
		1	Odor from pulp mills
		2	Other
23.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?________________________
		2	No.
		0	D.K.

Card No. 1

24.			Are there any other problems you think are serious or somewhat serious for Eureka?						
		1	serious						
		2	somewhat serious						
	26	3	not serious						
	26	0	D.K.						
25.			Do you know if there are any local or state authorities attempting to correct this problem?						
		1	Yes. What authority?______________________						
		2	No.						
		0	D.K.						
			Ask this question only if a "serious" or "somewhat serious" response has been given to at least one of the questions 15-25.						
26.			Have you ever thought of requesting, or have you actually requested some authority or agency to take action concerning any of these problems, e.g., by writing or phoning an official, signing a petition, or attending a meeting? If so, what problem was it?						
				Q 26 Pulp Mill Odors			Q 27 Pulp ~~Mill Odors or~~ Other		
		1	Type of Action	Requested	Thought of	No	Requested	Thought of	No
		2	Writing or phoning an official	1	2	3	1	2	3
		3							
27.		1	Signing a petition	1	2	3	1	2	3
	29	2							
	29	3	Attending a meeting	1	2	3	1	2	3
28.			Do you think this request has given or will give any results?						
		1	Yes, has given						
		2	Yes, might give						
		3	No						
		0	D.K.						

I will now ask some questions about some sources of noise and air pollution that may exist in most cities.

	Have you noticed here at home during the last three months?	How often? Is it 1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	Would you say it has bothered you 1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	How often has it bothered you? Is it 1 almost every time 2 about half the time 3 less often? 0 Don't know
Card 1	Yes No D.K.			
Traffic noise	1 2^a 0^a (29)	1 2 3 4 0 (30)	1 2 3 4^a 0^a (31)	1 2 3 0 (32)
Aircraft noise	1 2^a 0^a (33)	1 2 3 4 0 (34)	1 2 3 4^a 0^a (35)	1 2 3 0 (36)
Noise from industries What industries?				
________	1 2^a 0^a (37)	1 2 3 4 0 (38)	1 2 3 4^a 0^a (39)	1 2 3 0 (40)
________	1 2^a 0^a (41)	1 2 3 4 0 (42)	1 2 3 4^a 0^a (43)	1 2 3 0 (44)
________	1 2^a 0^a (45)	1 2 3 4 0 (46)	1 2 3 4^a 0^a (47)	1 2 3 0 (48)
Other kinds of noise What noise?				
________	1 2^a 0^a (49)	1 2 3 4 0 (50)	1 2 3 4^a 0^a (51)	1 2 3 0 (52)
________	1 2^a 0^a (53)	1 2 3 4 0 (54)	1 2 3 4^a 0^a (55)	1 2 3 0 (56)
________	1 2^a 0^a (57)	1 2 3 4 0 (58)	1 2 3 4^a 0^a (59)	1 2 3 0 (60)

	Have you noticed ________ here at home during the last three months?	How often? Is it 1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	Would you say it has bothered you 1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	How often has it bothered you? Is it 1 almost every time 2 about half the time 3 less often? 0 Don't know
Card 1	Yes No D.K.			
Dust or soot from industries What industries?				
________	1 2[a] 0[a] (61)	1 2 3 4 0 (62)	1 2 3 4[a] 0[a] (63)	1 2 3 0 (64)
________	1 2[a] 0[a] (65)	1 2 3 4 0 (66)	1 2 3 4[a] 0[a] (67)	1 2 3 0 (68)
________	1 2[a] 0[a] (69)	1 2 3 4 0 (70)	1 2 3 4[a] 0[a] (71)	1 2 3 0 (72)
Card 2				
Odors from industries What industries? Pulp mills (if mentioned spontaneously)				
________	1 2[a] 0[a] (1)	1 2 3 4 0 (2)	1[b] 2[c] 3[c] 4[a,b] 0[a,b] (3)	1 2 3 0 (4)
________	1 2[a] 0[a] (5)	1 2 3 4 0 (6)	1 2 3 4[a] 0[a] (7)	1 2 3 0 (8)
________	1 2[a] 0[a] (9)	1 2 3 4 0 (10)	1 2 3 4[a] 0[a] (11)	1 2 3 0 (12)
Smoke from tepee burners	1 2[a] 0[a] (13)	1 2 3 4 0 (14)	1 2 3 4[a] 0[a] (15)	1 2 3 0 (16)

	Have you noticed here at home during the last three months?	How often? Is it 1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	Would you say it has bothered you 1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	How often has it bothered you? Is it 1 almost every time 2 about half the time 3 less often? 0 Don't know
Card 2	Yes No D.K.			
Other kinds of air pollution What air pollution?				
__________	1 2[a] 0[a] (17)	1 2 3 4 0 (18)	1 2 3 4[a] 0[a] (19)	1 2 3 0 (20)
__________	1 2[a] 0[a] (21)	1 2 3 4 0 (22)	1 2 3 4[a] 0[a] (23)	1 2 3 0 (24)
__________	1 2[a] 0[a] (25)	1 2 3 4 0 (26)	1 2 3 4[a] 0[a] (27)	1 2 3 0 (28)

a Skip to next source.

b After question 28 skip to question 53 (Card 2), but give this introduction:
Some people here in Eureka have been complaining about odors from the pulp mills.

c After question 28 skip to question 33 (Card 2).

Card No. 2

			(Ask questions 29-32 only if the respondent has not already mentioned odor before.)
29.			Some people here in Eureka have been complaining about odors from the pulp mills.
			Here in your house have you noticed the odors during the last three months?
		1	Yes
	53	2	No
	53	0	D.K.
30.			How often have you noticed them? Is it
		1	every day
		2	at least once a week
		3	at least once a month
		4	or less often?
		0	D.K.
31.			Would you say that the odors have bothered you? (If yes) How much; is it
		1	only a little
		2	moderately
		3	very much?
		4	not at all
		0	D.K.
32.			How often has it bothered you? Is it
		1	almost every time you notice it
		2	about half the time
		3	less often?
		0	D.K.

Card No. 2

Do you get any of the following symptoms when you are bothered by the odors?

		Yes	No	D.K.
33.	Nervousness	1	2	0
34.	Headache	1	2	0
35.	Insomnia	1	2	0
36.	Fatigue	1	2	0
37.	Palpitation	1	2	0
38.	Dizziness	1	2	0
39.	Nausea	1	2	0
40.	Vomiting	1	2	0
41.	Sweating	1	2	0
42.	Sinus congestion	1	2	0
43.	Eye irritation	1	2	0
44.	Shortness of breath	1	2	0
45.	Burning or irritation of the nose	1	2	0
46.	Runny nose	1	2	0
47.	Chest pains	1	2	0
48.	Cough	1	2	0
49.	Other			

____

____

50.			You said the odors have bothered you. Do you think it's better, worse, or the same this summer as last summer?
		1	Better
	52	2	Worse
	53	3	The same
	53	0	D.K.

Card No. 2

51.			Do you think it's because there is less odor or because you have become used to it?
	53	1	Less odor
	53	2	Used to it
	53	0	D.K.
52.			Do you think it's because there is more odor or because you are more sensitive to it?
		1	More odor
		2	More sensitive
		0	D.K.
53.			If you consider advantages and disadvantages for the people in Eureka in having the pulp mills, do you think it is good or bad to have the pulp mills here?
		1	Good
		2	Bad
		0	D.K.
54.			Can you tell me about your general opinion about the problem of odor? Do you think that odors in general are
		1	very annoying
		2	annoying
		3	not too annoying
		4	not annoying at all?
		0	D.K.
55.			Do you think you are
		1	more sensitive than other people to odor
		2	less sensitive than other people to odor
		3	or about the same?
		0	D.K.

Card No. 2

56.			Do you think people here in Eureka have
		1	a greater problem with odor than other cities of its size
		2	a smaller problem with odor than other cities of its size
		3	about the same?
		0	D.K.
57.			We have also talked some about noise. Do you think noise in general is
		1	very annoying
		2	annoying
		3	not too annoying
		4	not annoying at all?
		0	D.K.
58.			Do you think you are
		1	more sensitive than other people to noise
		2	less sensitive than other people to noise
		3	or about the same?
		0	D.K.
59.			Do you think people here in Eureka have
		1	a greater noise problem than other cities of its size
		2	a smaller noise problem than other cities of its size
		3	or about the same?
		0	D.K.
60.			Do you think the authorities are too much concerned about air pollution, too little concerned about air pollution, or as much concerned as they should be?
		1	Too much
		2	Too little
		3	As much
		0	D.K.

Card No. 2

51.			Do you think the authorities are too much concerned about noise, too little concerned about noise, or as much concerned as they should be?
		1	Too much
		2	Too little
		3	As much
		0	D.K.

SECTION VII-B

EUREKA-1971

(Annoyance and Health Reactions)

I.D.______________ Date______________

Interviewer__________________

Introduction

I'm__________________________from the State Human Relations Agency. We are making a survey on how people feel about the community in which they live. I would like to ask you some questions about where you live and work.

Address____

____

Census Table

Household Member	Age	Sex	Marital Status	Occupation	Work Place	Education			
						E.S.	H.S.	C.E.	B.A.
I. F.						1	2	3	4
Spouse	--	--				1	2	3	4
Child 1		--				1	2	3	4
Child 2		--				1	2	3	4
Child 3		--				1	2	3	4
Child 4		--				1	2	3	4
Child 5		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4
-------		--				1	2	3	4

Ask marital status, occupation, work place, and education only for adults and for children at least 17 years old.

Respondent

61 Sex 1 M. 2 F. 62 Age 1 2 3 4

Marital 63 1 NM 2 M 3 W 4 D/S

			Husband						Wife		
Occupation	64	1 B.C.	2 W.C.	3 P.		65	1 B.C.	2 W.C.	3 P.	
Mill	66	1 Yes	2 No			67	1 Yes	2 No		
Location	68	1	2	3	4	69	1	2	3	4
Education	70	1 E.S.	2 H.S.	3 C.E.	4 B.A.	71	1 E.S.	2 H.S.	3 C.E.	4 B.A.

Household Size										
Total No.	72	1	2	3	4	5	6	7	8	9+
No. of Children less than 6	73	1	2	3	4	5	6	7	8	9+
6-16	74	1	2	3	4	5	6	7	8	9+
Adults	75	1	2	3	4	5	6	7	8	9+

Card No. 1

1. **Ask only if not obvious (check type of dwelling unit).**

Do you live in:

1 **a single house**

2 **a row house (town house)**

3 **an apartment house with less than 5 apartments**

4 **an apartment house with more than 5 apartments**

5 **trailer?**

6 other ______________________________

2. How many rooms are there in your home? __________

How many bedrooms are there in your home? __________

Does this include all the rooms used regularly for sleeping? __________

1

2 [Number of married couples plus number of single people __________]

3 (From table on p. 1)

4 [Determine code from table.]

5

3. What hours during the week days are you usually in your home?

Codes: Between 8:00 A.M. - [illegible]:00 P.M.

1

2 between ____ - ____

3 and between ____ - ____

4 If "other", such as traveler, working alternate shifts, explain here ____________

5

1	≤ 3 hours
2	4 - 6
3	7 - 9
4	10 - 12
5	other

Card No. 1

4.			How long a time have you lived in Eureka? ________
			How long a time have you lived in this residential area? ________
		1	How long a time have you lived in this house? Years ________ 1 Same house before pulp mills came
		2	2 Same residential area but different house
		3	3 Eureka but different residential area
		4	4 Moved into residential area after pulp mills came
5.			In general, how do you feel about living in this residential area? Do you rate it as an:
		1	good
		2	fair
	8	3	poor?
	8	0	D.K. (Don't know)
6.			What are some of the things you like about living around here - things that you feel are advantages or that make this a good place to live? ____ ____
7.			Nowadays, it is seldom that a residential area has advantages only. What about the things you don't like here? Would you say there is:
	9	1	nothing at all you don't like
		2	a few things or
		3	many things?
	9	0	D.K.

Card No. 1

8.			**What are some of the things you don't like about living here?**
		1	**odor from pulp mills**
		2	**odor from pulp mills and air pollution or noise or other pollution**
		3	**air pollution or noise or other pollution (without mention of pulp mills)**
		4	**other (without mention of any of the above)**
9.			Have you ever felt like moving away from this residential area?
		1	Yes
	13	2	No
	13	0	D.K.
10.			When you have felt like moving away, what has the reason been?
		1	odor from pulp mills
		2	odor from pulp mills and air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of pulp mills)
		4	other (without mention of any of the above)
11.			If you could find a similar apartment (house) which would not be more expensive in another residential area, would you like to move there?
		1	Yes
	13	2	No
	13	0	D.K.
12.			Why would you like to do this?
		1	odor from pulp mills
		2	odor from pulp mills and air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of pulp mills)
		4	Other (without mention of any of the above)

Card No. 1

13.			**Is there anything here in the community that you think is harmful for you or your family?**
		1	Yes
	15	2	No
	15	0	D.K.
14.			What is this?
		1	odor from pulp mills
		2	odor from pulp mills and air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of pulp mills)
		4	other (without mention of any of the above) ____
15.			Here are a few problems which different communities are facing. How would you rate each of these for Eureka today in terms of serious, somewhat serious, or not serious?
			Outbreaks of contagious diseases, such as whooping cough, diphtheria, etc.
		1	serious
		2	somewhat serious
	17	3	not serious
	17	0	D.K.
16.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?____________________________
		2	No.
		0	D.K.

Card No. 1

17.			**Water pollution**
		1	serious
		2	somewhat serious
	19	3	not serious
	19	0	D.K.
18.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?__________________________
		2	No
		0	D.K.
19.			Noise in the community or residential area.
		1	serious
		2	somewhat serious
	21	3	not serious
	21	0	D.K.
20.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?__________________________
		2	No.
		0	D.K.
21.			Air pollution.
		1	serious
		2	somewhat serious
	24	3	not serious
	24	0	D.K.
22.			What kind of air pollution are you thinking of?
		1	Odor from pulp mills
		2	Other
23.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?__________________________
		2	No.
		0	D.K.

Card No. 1

24.			Are there any other problems you think are serious or somewhat serious for Eureka?
		1	serious
		2	somewhat serious
	26	3	not serious
	26	0	D.K.
25.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?______________________________
		2	No.
		0	D.K.
			Ask this question only if a "serious" or "somewhat serious" response has been given to at least one of the questions 15-25.
26.			Have you ever thought of requesting, or have you actually requested some authority or agency to take action concerning any of these problems, e.g., by writing or phoning an official, signing a petition, or attending a meeting? If so, what problem was it?
		1	
		2	
		3	
27.		1	
	29	2	
	29	3	

Type of Action	Q 26 Pulp Mill Odors			Q 27 ~~Pulp Mill Odors or~~ Other		
	Requested	Thought of	No	Requested	Thought of	No
Writing or phoning an official	1	2	3	1	2	3
Signing a petition	1	2	3	1	2	3
Attending a meeting	1	2	3	1	2	3

28.			Do you think this request has given or will give any results?
		1	Yes, has given
		2	Yes, might give
		3	No
		0	D.K.

I will now ask some questions about some sources of noise and air pollution that may exist in most cities.

	Have you noticed here at home during the last three months?	How often? Is it	Would you say it has bothered you	How often has it bothered you? Is it
		1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	1 almost every time 2 about half the time 3 less often? 0 Don't know
Card 1	Yes No D.K.			
Traffic noise	1 2^a 0^a (29)	1 2 3 4 0 (30)	1 2 3 4^a 0^a (31)	1 2 3 0 (32)
Aircraft noise	1 2^a 0^a (33)	1 2 3 4 0 (34)	1 2 3 4^a 0^a (35)	1 2 3 0 (36)
Noise from industries What industries?				
__________	1 2^a 0^a (37)	1 2 3 4 0 (38)	1 2 3 4^a 0^a (39)	1 2 3 0 (40)
__________	1 2^a 0^a (41)	1 2 3 4 0 (42)	1 2 3 4^a 0^a (43)	1 2 3 0 (44)
__________	1 2^a 0^a (45)	1 2 3 4 0 (46)	1 2 3 4^a 0^a (47)	1 2 3 0 (48)
Other kinds of noise What noise?				
__________	1 2^a 0^a (49)	1 2 3 4 0 (50)	1 2 3 4^a 0^a (51)	1 2 3 0 (52)
__________	1 2^a 0^a (53)	1 2 3 4 0 (54)	1 2 3 4^a 0^a (55)	1 2 3 0 (56)
__________	1 2^a 0^a (57)	1 2 3 4 0 (58)	1 2 3 4^a 0^a (59)	1 2 3 0 (60)

	Have you noticed ______ here at home during the last three months?	How often? Is it	Would you say it has bothered you	How often has it bothered you? Is it
		1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	1 almost every time 2 about half the time 3 less often? 0 Don't know
Card 1	Yes No D.K.			
Dust or soot from industries What industries?				
______	1 2[a] 0[a] (61)	1 2 3 4 0 (62)	1 2 3 4[a] 0[a] (63)	1 2 3 0 (64)
______	1 2[a] 0[a] (65)	1 2 3 4 0 (66)	1 2 3 4[a] 0[a] (67)	1 2 3 0 (68)
______	1 2[a] 0[a] (69).	1 2 3 4 0 (70)	1 2 3 4[a] 0[a] (71)	1 2 3 0 (72)
Card 2				
Odors from industries What industries? Pulp mills (if mentioned spontaneously)				
______	1 2[a] 0[a] (1)	1 2 3 4 0 (2)	1[b] 2[c] 3[c] 4[a,b] 0[a,b] (3)	1 2 3 0 (4)
______	1 2[a] 0[a] (5)	1 2 3 4 0 (6)	1 2 3 4[a] 0[a] (7)	1 2 3 0 (8)
______	1 2[a] 0[a] (9)	1 2 3 4 0 (10)	1 2 3 4[a] 0[a] (11)	1 2 3 0 (12)
Smoke from tepee burners	1 2[a] 0[a] (13)	1 2 3 4 0 (14)	1 2 3 4[a] 0[a] (15)	1 2 3 0 (16)

	Have you noticed ______ here at home during the last three months?	How often? Is it 1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	Would you say it has bothered you 1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	How often has it bothered you? Is it 1 almost every time 2 about half the time 3 less often? 0 Don't know
Card 2	Yes No D.K.			
Other kinds of air pollution What air pollution?				
______	1 2^a 0^a (17)	1 2 3 4 0 (18)	1 2 3 4^a 0^a (19)	1 2 3 0 (20)
______	1 2^a 0^a (21)	1 2 3 4 0 (22)	1 2 3 4^a 0^a (23)	1 2 3 0 (24)
______	1 2^a 0^a (25)	1 2 3 4 0 (26)	1 2 3 4^a 0^a (27)	1 2 3 0 (28)

---

[a] Skip to next source.

[b] After question 28 skip to question 53 (Card 2), but give this introduction:
Some people here in Eureka have been complaining about odors from the pulp mills.

[c] After question 28 skip to question 33 (Card 2).

			(Ask questions 29-32 only if the respondent has not already mentioned odor before.)
29.			**Some people here in Eureka have been complaining about odors from the pulp mills.**
			Here in your house have you noticed the odors during the last three months?
		1	**Yes**
	33	2	**No**
	33	0	**D.K.**
30.			**How often have you noticed them? Is it**
		1	**every day**
		2	**at least once a week**
		3	**at least once a month**
		4	**or less often?**
		0	**D.K.**
31.			**Would you say that the odors have bothered you? (If yes) How much; is it**
		1	**only a little**
		2	**moderately**
		3	**very much?**
		4	**not at all**
		0	**D.K.**
32.			**How often has it bothered you? Is it**
		1	**almost every time you notice it**
		2	**about half the time**
		3	**less often?**
		0	**D.K.**

50.			You said the odors have bothered you. Do you think it's better, worse, or the same this summer as last summer?
		1	Better
	52	2	Worse
	53	3	The same
	53	0	D.K.

Card No. 2

51.			Do you think it's because there is less odor or because you have become used to it?
	53	1	Less odor
	53	2	Used to it
	53	0	D.K.
52.			Do you think it's because there is more odor or because you are more sensitive to it?
		1	More odor
		2	More sensitive
		0	D.K.
53.			If you consider advantages and disadvantages for the people in Eureka in having the pulp mills, do you think it is good or bad to have the pulp mills here?
		1	Good
		2	Bad
		0	D.K.
54.			Can you tell me about your general opinion about the problem of odor? Do you think that odors in general are
		1	very annoying
		2	annoying
		3	not too annoying
		4	not annoying at all?
		0	D.K.
55.			Do you think you are
		1	more sensitive than other people to odor
		2	less sensitive than other people to odor
		3	or about the same?
		0	D.K.

Card No. 2

56.			Do you think people here in Eureka have
		1	a greater problem with odor than other cities of its size
		2	a smaller problem with odor than other cities of its size
		3	about the same?
		0	D.K.
57.			We have also talked some about noise. Do you think noise in general is
		1	very annoying
		2	annoying
		3	not too annoying
		4	not annoying at all?
		0	D.K.
58.			Do you think you are
		1	more sensitive than other people to noise
		2	less sensitive than other people to noise
		3	or about the same?
		0	D.K.
59.			Do you think people here in Eureka have
		1	a greater noise problem than other cities of its size
		2	a smaller noise problem than other cities of its size
		3	or about the same?
		0	D.K.
60.			Do you think the authorities are too much concerned about air pollution, too little concerned about air pollution, or as much concerned as they should be?
		1	Too much
		2	Too little
		3	As much
		0	D.K.

Card No. 2

61.			Do you think the authorities are too much concerned about noise, too little concerned about noise, or as much concerned as they should be?
		1	Too much
		2	Too little
		3	As much
		0	D.K.

SECTION B

Use the actual wording of each question. ***Put X in appropriate square after each question.*** ***When in doubt record 'No'.***

PREAMBLE I am going to ask you some questions, mainly about your chest. I should like you to answer 'YES' or 'NO' whenever possible.

Card 3

COUGH

1. Do you usually cough first thing in the morning [on getting up*]? 1 ☐ Yes 2 ☐ No 1

Count a cough with first smoke or on first going out of doors. ***Exclude clearing throat or a single cough.***

3. Do you usually cough during the day - or at night? 1 ☐ Yes 2 ☐ No 2

Ignore an occasional cough.

If 'No' to both questions 1 and 3, go to question 6.

If 'Yes' to either question 1 or 3:

5. Do you cough like this on most days [or nights*] for as much as three months each year? 1 ☐ Yes 2 ☐ No 3 ☐ NA 3

PHLEGM

6. Do you usually bring up any phlegm from your chest first thing in the morning [on getting up*]? 1 ☐ Yes 2 ☐ No 4

Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.

8. Do you usually bring up any phlegm from your chest during the day - or at night? 1 ☐ Yes 2 ☐ No 5

Accept twice or more.

If 'No' to both questions 6 and 8, go to question 12a.

If 'Yes' to either question 6 or 8:

10. Do you bring up phlegm like this on most days [or nights*] for as much as three months each year? 1 ☐ Yes 2 ☐ No 3 ☐ NA 6

** For subjects who work at night.*

7

12a In the past three years have you had a period of [increased*] cough and phlegm lasting for three weeks or more? No ☐ 1

If 'No' to question 12a, go to question 11a

If 'Yes' to question 12a:

12b/c Have you had more than one such period? Yes-1 period ☐ 2

Yes-2 or more periods ☐ 3

**** For subjects who usually have phlegm.***

BREATHLESSNESS

9

14a. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? Disabled † ☐ 1

If 'No' to question 14a, go to question 21 No-a. ☐ 2

If 'Yes' to question 14a:

14b. Do you get short of breath walking with other people of your own age on level ground? No-b. ☐ 3

If 'No' to question 14b, go to question 21

If 'Yes' to question 14b:

14c. Do you have to stop for breath when walking at your own pace on level ground? No-c. ☐ 4

† Disabled from walking by any conditions other than heart or lung disease. Yes-c. ☐ 5

CHEST ILLNESSES

21. During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? No ☐ 1 16

If 'No' to question 21, go to question 22.

If 'Yes' to question 21:

21a. Did you bring up more phlegm than usual in any of these illnesses? No ☐ 2

If 'No' to question 21a, go to question 22.

If 'Yes' to question 21a. 1 illness ☐ 3

21b. How many illnesses like this have you had in the past three years? 2 or more illnesses ☐ 4

---

22. Were you sick at any time last week or the week before? Yes ☐ 1 No ☐ 2 17

(Week ends Sunday at midnight.)

If 'Yes': What was the matter? ____________________

____

Anything else? ____________________

____

23. Have you been to a doctor within the last two weeks? ☐ ☐ 18

24. Have you been a patient in a hospital within the last two weeks? ☐ ☐ 19

25. I am going to read you a list of symptoms and I should like you to tell me whether you have each one frequently, occasionally or hardly ever.

How often do you have ________? Would you say you have it frequently, occasionally, or hardly ever?	Frequently	Occasionally	Hardly Ever Or Not At All	
Nervousness	1 ☐	2 ☐	3 ☐	33
Headache	1 ☐	2 ☐	3 ☐	34
Sleeplessness	1 ☐	2 ☐	3 ☐	35
Dizziness, nausea or vomiting	1 ☐	2 ☐	3 ☐	36
Constipation	1 ☐	2 ☐	3 ☐	38
Pain in joints	1 ☐	2 ☐	3 ☐	39
Difficulty in urinating	1 ☐	2 ☐	3 ☐	40
Sinus congestion	1 ☐	2 ☐	3 ☐	42
Eye irritation	1 ☐	2 ☐	3 ☐	43
Burning or irritation of the nose	1 ☐	2 ☐	3 ☐	45
Runny nose	1 ☐	2 ☐	3 ☐	46
Chest pains	1 ☐	2 ☐	3 ☐	47

26. **Would you say that your health in general is**

Excellent	☐	(1)	48
Good	☐	(2)	
Fair	☐	(3)	
Poor?	☐	(4)	
Don't know	☐	(0)	

27. **Have you worked for a year or more in a dusty job?**

Yes	☐	(1)	49
No	☐	(2)	

Total number of years in dusty job? .... 50 ☐ 51 ☐

TOBACCO SMOKING

55a. Do you smoke? ☐ Yes ☐ No

Record 'Yes' if regular smoker (as defined in question 55b) up to one month ago.

If 'No' to question 55a, ask question 55b.

If 'Yes' to question 55a:

Do you inhale the smoke? ☐ Yes ☐ No

Would you say you inhale the smoke slightly (S), moderately (M), deeply (D)? ☐ S ☐ M ☐ D

How old were you when you started smoking regularly? ____ years old

How many manufactured cigarettes do you usually smoke per day? ____ per working day

____ at weekends

How much tobacco (oz/g) do you usually smoke per week in hand-rolled cigarettes? __________

How much pipe tobacco (oz/g) do you usually smoke per week? __________

How many cigars do you usually smoke per week? __________

Specify large (L) or small (S).

55b. Have you ever smoked as much as one cigarette a day [or one ounce of tobacco a month] for as long as a year? ☐ Yes ☐ No

If 'No' to question 55b, go to question 56.

If 'Yes' to question 55b:

How old were you when you started smoking regularly? ____ years old

How old were you when you last gave up smoking? ____ years old

How many manufactured cigarettes per day were you smoking before you gave up? ____ per working day

____ at weekends

How much tobacco (oz/g) per week were you smoking in hand-rolled cigarettes before you gave up? __________

How much pipe tobacco (oz/g) per week were you smoking before you gave up? __________

How many cigars per week were you smoking before you gave up? __________

Specify large (L) or small (S).

CODING FOR SMOKING HISTORY

Before coding refer to instructions.

Smoking history

Never smoked	☐ 1	52
Ex-smoker	☐ 2	
Present smoker - does not inhale	☐ 3	
Present smoker - inhales slightly	☐ 4	
Present smoker - inhales moderately	☐ 5	
Present smoker - inhales deeply	☐ 6	

Type of smoker

Cigarettes only	☐ 1	53
Pipe only	☐ 2	
Cigars only	☐ 3	
Cigarettes and pipe/cigars	☐ 4	
Cigars and pipe	☐ 5	
Non-smoker	☐ 6	

Amount smoked per day* (average including weekends)

Cigarette tobacco		
Nil	☐ 1	54
1-4 g	☐ 2	
5-14 g	☐ 3	
15-24 g	☐ 4	
25-34 g	☐ 5	
35 g or more	☐ 6	
Pipe/cigar tobacco:		
Nil	☐ 1	55
1-4 g	☐ 2	
5-14 g	☐ 3	
15-24 g	☐ 4	
25-34 g	☐ 5	
35 g or more	☐ 6	

** 1 oz of pipe tobacco =28 cigarettes=28 g*
1 small cigar = 2 cigarettes
1 large cigar = 5 cigarettes

		56	57
Age started (years)	Code 00 if a non-smoker	☐	☐
		58	59
Age stopped (years)	Code 00 if a present smoker	☐	☐

SECTION VII-C

ANDERSON-1970-INTERVIEW

(Health Reactions)

HEALTH QUESTIONNAIRE
SEPTEMBER, 1970

Before the interview the booklet of instructions should be read.

		Card 2			
	Day	Month	Year	
DATE OF INTERVIEW	☐	☐	☐	52-56
DATE OF BIRTH	☐	☐	☐	57-62

	M	F		
SEX	☐ 1	☐ 2		63

	S	M	W	
CIVIL STATE	☐ 1	☐ 2	☐ 3	64

SURVEY No.
(Cards 1 & 2) 76-79
Card 1 col 80 code 1
Card 2 col 80 code 2

NAME - Surname - First Name

Address

How long have you lived at this address? 70-71

How long have you lived in this residential area? 72-73

How long have you lived in Anderson? 74-75

OCCUPATION	☐	65
INDUSTRY	☐	66
RACE	☐	67
NAME OF INTERVIEWER	☐	68
Blank		69

Use the actual wording of each question. Put X in appropriate square after each question. When in doubt record 'No'.

PREAMBLE I am ____ going to ask you some questions, mainly about your chest. I should like you to answer 'YES' or 'NO' whenever possible.

COUGH

1. Do you usually cough first thing in the morning [on getting up*]? ☐ 1 Yes ☐ 2 No — 1

Count a cough with first smoke or on first going out of doors. Exclude clearing throat or a single cough.

3. Do you usually cough during the day - or at night? ☐ 1 Yes ☐ 2 No — 2

Ignore an occasional cough.

If 'No' to both questions 1 and 3, go to question 6.

If 'Yes' to either question 1 or 3:

5. Do you cough like this on most days [or nights*] for as much as three months each year? ☐ 1 Yes ☐ 2 No ☐ 9 NA — 3

PHLEGM

6. Do you usually bring up any phlegm from your chest first thing in the morning [on getting up*]? ☐ 1 Yes ☐ 2 No — 4

Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.

8. Do you usually bring up any phlegm from your chest during the day - or at night? ☐ 1 Yes ☐ 2 No — 5

Accept twice or more.

If 'No' to both questions 6 and 8, go to question 12a.

If 'Yes' to either question 6 or 8:

10. Do you bring up phlegm like this on most days [or nights*] for as much as three months each year? ☐ 1 Yes ☐ 2 No ☐ 9 NA — 6

* *For subjects who work at night.*

		7	
12a In the past three years have you had a period of **[increased*] cough and phlegm** lasting for three weeks or more?	No	☐	1
If 'No' to question 12a, go to question 13.			
If 'Yes' to question 12a:			
12b/c. Have you had more than one such period?	Yes-1 period	☐	2
** For subjects who usually have phlegm.*	Yes-2 or more periods	☐	3
		8	
13. Have you ever coughed up blood?	No	☐	1
If 'No' to question 13, go to question 14a.			
If 'Yes' to question 13:	Yes-in past year	☐	2
13a. Was this in the past year?	Yes-not in past year	☐	3

BREATHLESSNESS

		9	
14a. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?	Disabled †	☐	1
If 'No' to question 14a, go to question 15a.	No-a.	☐	2
If 'Yes' to question 14a:			
14b. Do you get short of breath walking with other people of your own age on level ground?	No-b.	☐	3
If 'No' to question 14b, go to question 15a.			
If 'Yes' to question 14b:			
14c. Do you have to stop for breath when walking at your own pace on level ground?	No-c.	☐	4
† Disabled from walking by any conditions other than heart or lung disease.	Yes-c.	☐	5

WHEEZING

		10	
15a. Does your chest ever sound wheezing or whistling?	No	☐	1
If 'No' to question 15a, go to question 16a.			
If 'Yes' to question 15a:	Yes, but not most days [or nights]	☐	2
15b. Do you get this most days - or nights?	Yes, most days [or nights]	☐	3
		11	
16a. Have you ever had attacks of shortness of breath with wheezing?	No attacks	☐	1
If 'No' to question 16a, go to question 17.			
If 'Yes' to question 16a:	No	☐	2
16b. Is/was your breathing absolutely normal between attacks?	Yes	☐	3

WEATHER

		12	
17. Does the weather affect your chest? *Only record 'Yes' if adverse weather definitely and regularly causes chest symptoms.*	No	☐	1
If 'No' to question 17, go to question 18.	Yes	☐	2
If 'Yes' to question 17:			
17a. Does the weather make you short of breath?	No	☐	3
		13	
17b. Specify type of weather, e.g. fog, damp, cold, heat, other		☐	

NASAL CATARRH

18. Do you usually have a stuffy nose or catarrh at the back of your nose? ☐ Yes 1 ☐ No 2 14

20. Do you have this on most days for as much as three months each year? ☐ Yes 1 ☐ No 2 ☐ NA 9 15

CHEST ILLNESSES

21. During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? No ☐ 1 16

If 'No' to question 21, go to question 22.

If 'Yes' to question 21:

21a. Did you bring up more phlegm than usual in any of these illnesses? No ☐ 2

If 'No' to question 21a, go to question 22.

If 'Yes' to question 21a:

21b. How many illnesses like this have you had in the past three years?
1 illness ☐ 3
2 or more illnesses ☐ 4

HAVE YOU EVER HAD:

22. An injury or operation affecting your chest? .... ☐ 17
23. Heart trouble? .... ☐ 18
24. Bronchitis? .... ☐ 19
25. Pneumonia? .... ☐ 20
26. Pleurisy? .... ☐ 21
27. Pulmonary tuberculosis? .... ☐ 22
28. Bronchial asthma? .... ☐ 23
29. Allergies .... ☐ 24
30. Hay fever .... ☐ 25
31. Emphysema? .... ☐ 26
32. Bronchiectasis? .... ☐ 27
33. Other chest trouble? .... ☐ 28
34. Chronic skin problems? .... ☐ 29
35. Cancer? .... ☐ 30
36. Blood condition or anemia? .... ☐ 31

† Code 0=no, 1=yes.

---

37. Were you sick at any time last week or the week before? Yes ☐ 1 No ☐ 2 32
(Week ends Sunday at midnight.)
If 'Yes': What was the matter? ______________________________
____
Anything else? ______________________________
____

I am going to read a list of symptoms. For each one I should like you to tell me whether you have it frequently, occasionally, or hardly ever:

		How often do you have ______?					Ask for each symptom with positive answer: Is there anything in particular which seems to bring the ______ on?		Ask for each symptom with positive answer: Did you have ____ last week or the week before?			
		Frequently	Occasionally	Hardly ever	Don't know				Yes	No	DK	
38.	Nervous	1	2	3	0	(33)	______	(50)	1	2	0	(7)
39.	Headache	1	2	3	0	(34)	______	(51)	1	2	0	(8)
40.	Insomnia	1	2	3	0	(35)	______	(52)	1	2	0	(9)
41.	Fatigue	1	2	3	0	(36)	______	(53)	1	2	0	(10)
42.	Palpitations	1	2	3	0	(37)	______	(54)	1	2	0	(11)
43.	Dizziness	1	2	3	0	(38)	______	(55)	1	2	0	(12)
44.	Nausea	1	2	3	0	(39)	______	(56)	1	2	0	(13)
45.	Vomiting	1	2	3	0	(40)	______	(57)	1	2	0	(14)
46.	Sweating	1	2	3	0	(41)	______	(58)	1	2	0	(15)
47.	Sinus congestion	1	2	3	0	(42)	______	(59)	1	2	0	(16)
48.	Eye irritation	1	2	3	0	(43)	______	(60)	1	2	0	(17)
49.	Shortness of breath	1	2	3	0	(44)	______	(1)	1	2	0	(18)
50.	Burning or irritation of the nose	1	2	3	0	(45)	______	(2)	1	2	0	(19)
51.	Runny nose	1	2	3	0	(46)	______	(3)	1	2	0	(20)
52.	Chest pains	1	2	3	0	(47)	______	(4)	1	2	0	(21)
53.	Cough	1	2	3	0	(48)	______	(5)	1	2	0	(22)
54.	Other	1	2	3	0	(49)	______	(6)	1	2	0	(23)
	______						______					
	______						______					
	______						______					
	______						______					

Would you say that your health in general is

Excellent ☐ (1)
Good ☐ (2)
Fair ☐ (3)
Poor? ☐ (4)
Don't know ☐ (0)

TOBACCO SMOKING

55a. Do you smoke? ☐ Yes ☐ No

Record 'Yes' if regular smoker (as defined in question 55b) up to one month ago.

If 'No' to question 55a, ask question 55b.

If 'Yes' to question 55a:

Do you inhale the smoke? ☐ Yes ☐ No

Would you say you inhale the smoke slightly (S), moderately (M), deeply (D)? ☐ S ☐ M ☐ D

How old were you when you started smoking regularly? ____ years old

How many manufactured cigarettes do you usually smoke per day? ____ per working day

____ at weekends

How much tobacco (oz/g) do you usually smoke per week in hand-rolled cigarettes? ________

How much pipe tobacco (oz/g) do you usually smoke per week? ________

How many cigars do you usually smoke per week? ________

Specify large (L) or small (S).

55b. Have you ever smoked as much as one cigarette a day [or one ounce of tobacco a month] for as long as a year? ☐ Yes ☐ No

If 'No' to question 55b, go to question 56.

If 'Yes' to question 55b:

How old were you when you started smoking regularly? ____ years old

How old were you when you last gave up smoking? ____ years old

How many manufactured cigarettes per day were you smoking before you gave up? ____ per working day

____ at weekends

How much tobacco (oz/g) per week were you smoking in hand-rolled cigarettes before you gave up? ________

How much pipe tobacco (oz/g) per week were you smoking before you gave up? ________

How many cigars per week were you smoking before you gave up? ________

Specify large (L) or small (S)

CODING FOR SMOKING HISTORY

Before coding refer to instructions

Smoking history 24

- Never smoked ☐ 1
- Ex-smoker ☐ 2
- Present smoker - does not inhale ☐ 3
- Present smoker - inhales slightly ☐ 4
- Present smoker - inhales moderately ☐ 5
- Present smoker - inhales deeply ☐ 6

Type of smoker 25

- Cigarettes only ☐ 1
- Pipe only ☐ 2
- Cigars only ☐ 3
- Cigarettes and pipe/cigars ☐ 4
- Cigars and pipe ☐ 5
- Non-smoker ☐ 6

Amount smoked per day* (average including weekends) 26

Cigarette tobacco:

- Nil ☐ 1
- 1-4 g ☐ 2
- 5-14 g ☐ 3
- 15-24 g ☐ 4
- 25-34 g ☐ 5
- 35 g or more ☐ 6

Pipe/cigar tobacco: 27

- Nil ☐ 1
- 1-4 g ☐ 2
- 5-14 g ☐ 3
- 15-24 g ☐ 4
- 25-34 g ☐ 5
- 35 g or more ☐ 6

** 1 oz of pipe tobacco = 28 cigarettes = 28 g*
1 small cigar = 2 cigarettes
1 large cigar = 5 cigarettes

		28	29
Age started (years)	Code 00 if a non-smoker	☐	☐
		30	31
Age stopped (years)	Code 00 if a present smoker	☐	☐

OCCUPATION

Record on dotted lines number of years in which subject has worked in any of these industries.

56. Have you ever worked in a dusty job

		1	2	
a.	At a coalmine?	☐ Yes	☐ No	32
b.	In any other mine?	☐ Yes	☐ No	33
c.	In a quarry?	☐ Yes	☐ No	34
d.	In a foundry?	☐ Yes	☐ No	35
e.	In a pottery?	☐ Yes	☐ No	36
f.	In a cotton, flax or hemp mill?	☐ Yes	☐ No	37
g.	With asbestos?	☐ Yes	☐ No	38
h.	In any other dusty job?	☐ Yes	☐ No	39

If 'Yes', specify ....

Have you worked for a year or more in a dusty job?

43

Yes ☐ (1)
No ☐ (2)

57. Total number of years in dusty job? .... 40 ☐ 41 ☐

58a. Have you been exposed regularly to irritating gas or chemical fumes?

If 'Yes', give details of nature and durat.on.

....

....

....

	42
Yes 58 a and b	☐ 1
No 58 a and b	☐ 2
Yes 58a No 58b	☐ 3

58b. Have you ever been off work for a shift or longer following acute exposure to gases or fumes?

If 'Yes', give details of nature and duration.

....

....

No 58a Yes 58b	☐ 4

Coding only (card 2)

Health col 44 code

Blank col 45-50

Resume punching on page 1

SECTION VII-D
ANDERSON-1970-POSTAL
(Health Reactions)

HEALTH QUESTIONNAIRE
MARCH, 1971

47-50
Today's Date
☐ ☐ ☐
Month Day Year 51-56

PLEASE ANSWER EACH OF THE FOLLOWING QUESTIONS

NAME

ADDRESS

Date of Birth 57-62
Month Day Year

Sex 63
☐ Male ☐ Female

Are you: 64
☐ Single ☐ Married
☐ Widowed ☐ Divorced or Separated

Are you:
☐ Employed ☐ Student ☐ Retired
☐ Housewife ☐ Disabled ☐ Other

What kind of work do you do? 65

In what type of business or industry do you work? 66

MARRIED WOMEN: What kind of work does your husband do?

What type of business or industry does he work in?

How long have you lived at this address? 70-71

How long have you lived in Anderson? 74-75

PLEASE ANSWER THE FOLLOWING QUESTIONS BY PLACING AN ☒ IN THE BOXES MARKED "YES" OR "NO".

1. Do you usually cough first thing in the morning? 1 ☐ Yes 2 ☐ No 1

Count a cough with first smoke or on first going out of doors.
Exclude clearing throat or a single cough.

2. Do you usually cough during the day or at night? 1 ☐ Yes 2 ☐ No 2

Ignore an occasional cough.

IF YOU HAVE ANSWERED "YES" TO EITHER QUESTIONS 1 OR 2:

3. Do you cough like this on most days for as much as three months each year? 1 ☐ Yes 2 ☐ No 3

4. Do you usually bring up any phlegm from your chest first thing in the morning? 1 ☐ Yes 2 ☐ No 4

Count phlegm with the first smoke or on first going out of doors.
Exclude phlegm from the nose. Count swallowed phlegm.

5. Do you usually bring up any phlegm from your chest during the day or at night? 1 ☐ Yes 2 ☐ No 5

Count twice or more.

IF YOU HAVE ANSWERED "YES" TO EITHER QUESTIONS 4 OR 5:

6. Do you bring up phlegm like this on most days or nights for as much as three months each year? 1 ☐ Yes 2 ☐ No 6

7. In the past three years have you had a period of increased cough and phlegm lasting for three weeks or more?	☐ Yes	1 ☐ No	7
If "Yes":			
7a. Have you had more than one such period?	3 ☐ Yes	2 ☐ No	
8. Have you ever coughed up blood?	☐ Yes	1 ☐ No	8
If "Yes":			
8a. Was this in the past year?	3 ☐ Yes	2 ☐ No	
9. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?	☐ Yes	2 ☐ No	9
10. Do you get short of breath walking with other people of your own age on level ground?	☐ Yes	3 ☐ No	
11. Do you have to stop for breath when walking at your own pace on level ground?	5 ☐ Yes	4 ☐ No	
12. Does your chest ever sound wheezing or whistling?	☐ Yes	1 ☐ No	10
If "Yes":			
12a. Do you get this most days or nights?	3 ☐ Yes	2 ☐ No	
13. Have you ever had attacks of shortness of breath with wheezing?	☐ Yes	1 ☐ No	11
If "Yes":			
13a. Is/was your breathing absolutely normal between attacks?	3 ☐ Yes	2 ☐ No	
14. Does the weather affect your chest?	☐ Yes	1 ☐ No	12
If "Yes":			
What kind of weather affects your chest? ________________ (Please write in answer)			13
14a. Does the weather make you short of breath?	2 ☐ Yes	3 ☐ No	
15. Do you usually have a stuffy nose or catarrh at the back of your nose?	1 ☐ Yes	2 ☐ No	14
If "Yes":			
15a. Do you have this on most days for as much as three months each year?	1 ☐ Yes	2 ☐ No	15

16. During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? ☐ Yes 1 ☐ No 16

If "Yes":

16a. Did you bring up more phlegm than usual in any of these illnesses? ☐ Yes 2 ☐ No

If "Yes":

16b. Have you had more than one illness like this in the past three years? 4 ☐ Yes 3 ☐ No

---

17. Have you ever had:

An injury or operation affecting your chest?	1 ☐ Yes	0 ☐ No	17
Heart trouble?	1 ☐ Yes	0 ☐ No	18
Bronchitis?	1 ☐ Yes	0 ☐ No	19
Pneumonia?	1 ☐ Yes	0 ☐ No	20
Pleurisy?	1 ☐ Yes	0 ☐ No	21
Pulmonary tuberculosis?	1 ☐ Yes	0 ☐ No	22
Bronchial asthma?	1 ☐ Yes	0 ☐ No	23
Allergies?	1 ☐ Yes	0 ☐ No	24
Hay fever?	1 ☐ Yes	0 ☐ No	25
Emphysema?	1 ☐ Yes	0 ☐ No	26
Bronchiectasis?	1 ☐ Yes	0 ☐ No	27
Other chest trouble?	1 ☐ Yes	0 ☐ No	28
Chronic skin problems?	1 ☐ Yes	0 ☐ No	29
Cancer?	1 ☐ Yes	0 ☐ No	30
Blood condition or anemia?	1 ☐ Yes	0 ☐ No	31

---

18. Were you sick at any time during the last two weeks? 1 ☐ Yes 2 ☐ No 32

If "Yes":

What was the matter? ________________________________

____

____

Anything else? ________________________________

____

____

____

PLEASE COMPLETE THE FOLLOWING TABLE BY PLACING AN ☒ IN THE APPROPRIATE BOX

19. How often do you have each of the following?	Frequently	Occasionally	Hardly Ever Or Not At All		FOR EACH SYMPTOM FOR WHICH YOU CHECKED "FREQUENTLY" OR "OCCASIONALLY": Is there anything in particular which seems to bring this on? (WRITE IN ANSWER)	Did you have any of these symptoms during the last two weeks?	YES	NO	
Nervousness	1 ☐	2 ☐	3 ☐	33	50	Nervousness	1 ☐	2 ☐	7
Headache	1 ☐	2 ☐	3 ☐	34	51	Headache	1 ☐	2 ☐	8
Insomnia	1 ☐	2 ☐	3 ☐	35	52	Insomnia	1 ☐	2 ☐	9
Fatigue	1 ☐	2 ☐	3 ☐	36	53	Fatigue	1 ☐	2 ☐	10
Palpitations	1 ☐	2 ☐	3 ☐	37	54	Palpitations	1 ☐	2 ☐	11
Dizziness	1 ☐	2 ☐	3 ☐	38	55	Dizziness	1 ☐	2 ☐	12
Nausea	1 ☐	2 ☐	3 ☐	39	56	Nausea	1 ☐	2 ☐	13
Vomiting	1 ☐	2 ☐	3 ☐	40	57	Vomiting	1 ☐	2 ☐	14
Sweating	1 ☐	2 ☐	3 ☐	41	58	Sweating	1 ☐	2 ☐	15
Sinus congestion	1 ☐	2 ☐	3 ☐	42	59	Sinus congestion	1 ☐	2 ☐	16
Eye irritation	1 ☐	2 ☐	3 ☐	43	60	Eye irritation	1 ☐	2 ☐	17
Shortness of breath	1 ☐	2 ☐	3 ☐	44	1	Shortness of breath	1 ☐	2 ☐	18
Burning or irritation of the nose	1 ☐	2 ☐	3 ☐	45	2	Burning or irritation of the nose	1 ☐	2 ☐	19
Runny nose	1 ☐	2 ☐	3 ☐	46	3	Runny nose	1 ☐	2 ☐	20
Chest pains	1 ☐	2 ☐	3 ☐	47	4	Chest pains	1 ☐	2 ☐	21
Cough	1 ☐	2 ☐	3 ☐	48	5	Cough	1 ☐	2 ☐	22
Other (specify)	1 ☐	2 ☐	3 ☐	49	6	Other (specify)	1 ☐	2 ☐	23

Would you say that your health in general is

1 ☐ Excellent 2 ☐ Good 3 ☐ Fair 4 ☐ Poor

21. Do you smoke? ☐ Yes ☐ No

21a. If "Yes", **ANSWER THESE QUESTIONS:**

Do you inhale the smoke?

Would you say you inhale the smoke:

☐ Slightly ☐ Moderately ☐ Deeply

How old were you when you started smoking regularly? _______ years old.

How much do you usually smoke? **PLEASE FILL IN AMOUNT BELOW**

Manufactured cigarettes _______ Number per **WORKING DAY**
_______ Number per **DAY** on **WEEKENDS**
Handrolled cigarettes _______ Ounces of tobacco per **WEEK**
Pipe tobacco _______ Ounces of tobacco per **WEEK**
Cigars _______ Number of **LARGE** cigars per **WEEK**
_______ Number of **SMALL** cigars per **WEEK**

21b. If "No"; **ANSWER THESE QUESTIONS:**

Have you ever smoked as much as one cigarette a day or one ounce of tobacco a month, for as long as a year?

How old were you when you started smoking regularly? _______ years old.

How old were you when you last gave up smoking? _______ years old.

How much were you smoking then? **PLEASE FILL IN AMOUNTS BELOW**

Manufactured cigarettes _______ Number per **WORKING DAY**
_______ Number per **DAY** on **WEEKENDS**
Handrolled cigarettes _______ Ounces of tobacco per **WEEK**
Pipe tobacco _______ Ounces of tobacco per **WEEK**
Cigars _______ Number of **LARGE** cigars per **WEEK**
_______ Number of **SMALL** cigars per **WEEK**

FOR OFFICE USE ONLY
☐ 24
☐ 25
☐ 26
☐ 27
☐☐ 28-29
☐☐ 30-31

22. Have you ever worked in a dusty job

	1 YES	2 NO	No. of Years	
a. At a coal mine?	☐	☐	____	32
b. In any other mine?..	☐	☐	____	33
c. In a quarry?	☐	☐	____	34
d. In a foundry?	☐	☐	____	35
e. In a pottery?	☐	☐	____	36
f. In a cotton, flax or hemp mill?	☐	☐	____	37
g. With asbestos?	☐	☐	____	38
h. In any other dusty job?	☐	☐	____	39

If "Yes", specify: ______________________

23. How many years altogether have you worked in a dusty job? ______ years.
40-41

24. Have you been exposed regularly to irritating gas or chemical fumes?

☐ Yes ☐ No

If 'Yes':

What was it? ______________________

____

When? ______________________

For how long? ______________________

25. Have you ever been off work for a shift or longer following acute exposure to gases or fumes?

☐ Yes ☐ No

If 'Yes':

What was it? ______________________

____

When? ______________________

For how long? ______________________

FOR OFFICE USE ONLY

☐ 42

☐ 44

SECTION VII-8

CARSON-1971

(Annoyance and Health Reaction)

SURVEY QUESTIONNAIRE

January, 1972

I.D.____________
77-79(cards 1,2,3)

Date________

Interviewer____________
73(card 1)

Name____

Address____

Introduction

I'm ____________ from the State Human Relations Agency. We are making a survey on how people feel about the community in which they live. I would like to ask you some questions about where you live and work.

Section I

Census Table

Household Member	Age	Sex	Marital Status	Occupation	Work Place	Education			
						E.S.	H.S	C.E.	B.A.
I.P.						1	2	3	4
Spouse						1	2	3	4
Child 1						1	2	3	4
Child 2						1	2	3	4
Child 3						1	2	3	4
Child 4						1	2	3	4
Child 5						1	2	3	4
						1	2	3	4

ASK MARITAL STATUS, OCCUPATION, WORK PLACE AND EDUCATION ONLY FOR ADULTS AND FOR CHILDREN AT LEAST 17 YEARS OLD. INDICATE MARRIED COUPLES BY BRACKETS OR ARROWS IF MORE THAN ONE COUPLE LIVES IN THE HOUSEHOLD

Section II

Card No. 1

1.			Ask only if not obvious (check type of dwelling unit).	
			Do you live in:	
		1	a single house	
		2	a row house (town house)	
		3	an apartment house with less than 5 apartments	
		4	an apartment house with more than 5 apartments	
		5	trailer?	
		6	other________________________	
2.		1	How many rooms are there in your home?__________	
		2	How many bedrooms are there in your home?________	
		3	Does this include all the rooms used regularly for sleeping?__________	
		4		
		5	DO NOT ENTER CODE AT LEFT.	
3.			What hours during the week days are you usually in your home?	
		1		Codes: Between 8:00 AM - 8:00 PM
		2	between____ - ____	1 _ 3 hours
		3	and between____ - ____	2 4 - 6
		4	If "other", such as traveler,	3 7 - 9
		5	working alternate shifts,	4 10 - 12
			explain here________________	5 other
			DO NOT ENTER CODE AT LEFT	

Card No. 1

				Years
4.		1	How long a time have you lived in Carson?	________
		2	How long a time have you lived in this	
		3	residential area?	________
		4	How long a time have you lived in this	
			house?	________
			DO NOT ENTER CODE AT LEFT	
5.			In general, how do you feel about living in this residential area? Do you rate it as:	
		1	good	
		2	fair	
	8	3	poor?	
	8	0	D.K. (Don't know)	
6.			What are some of the things you like about living around here - things that you feel are advantages or that make this a good place to live?	
			________________________________	
			________________________________	
7.			Nowadays it is seldom that a residential area has advantages only. What about the things you don't like here? Would you say there is:	
	9	1	nothing at all you don't like	
		2	a few things or	
		3	many things?	
	9	0	D.K.	

Card No. 1

8.			What are some of the things you don't like about living here?
		1	odor from industry
		2	odor from industry and any one of the following air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of odor from industry)
		4	other (without mention of any of the above)
9.			Have you ever felt like moving away from this residential area?
		1	Yes
	13	2	No
	13	0	D.K.
10.			When you felt like moving away, what has the reason been?
		1	odor from industry
		2	odor from industry and any one of the following: air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of odor from industry)
		4	other (without mention of any of the above)
11.			If you could find a similar apartment (house) which would not be more expensive in another residential,area, would you like to move there?
		1	Yes
	13	2	No
	13	0	D.K.

Card No. 1

12.			Why would you like to do this?
		1	odor from industry
		2	odor from industry and any one of the following: air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of odor from industry)
		4	other (without mention of any of the above)
13.			Is there anything here in the community that you think is harmful for you or your family?
		1	Yes
	15	2	No
	15	0	D.K.
14.			What is this?
		1	odor from industry
		2	odor from industry and any one of the following: air pollution or noise or other pollution
		3	air pollution or noise or other pollution (without mention of odor from industry)
		4	other (without mention of any of the above)

Card No. 1

14a			IF ODOR IS MENTIONED IN QUESTIONS 8-14, ASK THE FOLLOWING:
		1	
		2	Where do you think these odors come from?
		3	________________________________
		4	________________________________
		5	________________________________
		6	
15.			Here are a few problems which different communities are facing. How would you rate each of these for Carson today in terms of serious, somewhat serious or not serious?
			Outbreaks of contagious diseases, such as whooping cough, diphtheria, etc.
		1	serious
		2	somewhat serious
	17	3	not serious
	17	0	D.K.
16.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?____________________
		2	No
		0	D.K.

Card No. 1

17.			Water pollution
		1	serious
		2	somewhat serious
	19	3	not serious
	19	0	D.K.
18.			Do you know if there are any local or state a authorities attempting to correct this problem?
		1	Yes. What authority?____________________
		2	No
		0	D.K.
19.			Noise in the community or residential area.
		1	serious
		2	somewhat serious
	21	3	not serious
	21	0	D.K.
20.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?____________________
		2	No
		0	D.K.

Card No. 1

21.			Air pollution
		1	serious
		2	somewhat serious
	24	3	not serious
	24	0	D.K.
22.			What kind of air pollution are you thinking of?
		1	odor from industry
		2	other
23.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?____________________
		2	No
		0	D.K.
24.			Are there any other problems you think are serious or somewhat serious for Carson?____________________
		1	serious
		2	somewhat serious
	26	3	not serious
	26	0	D.K.
25.			Do you know if there are any local or state authorities attempting to correct this problem?
		1	Yes. What authority?____________________
		2	No
		0	D.K.

Card No. 1

ASK QUESTIONS 26 & 27 ONLY IF A "SERIOUS" OR "SOMEWHAT SERIOUS" RESPONSE HAS BEEN GIVEN TO AT LEAST ONE OF THE QUESTIONS 15-25.

Have you ever thought of requesting, or have you actually requested some authority or agency to take action concerning any of these problems, e.g., by writing or phoning an official, signing a petition, or attending a meeting? If so, what problem was it?

26. Q.26 Odors from Industry

	Type of Action	Requested	Thought of	No
1	Writing or phoning an official	1	2	3
2	Signing a petition	1	2	3
3	Attending a meeting	1	2	3

27. Q.27 Other Problems

	Type of Action	Requested	Thought of	No
1	Writing or phoning an official	1	2	3
2	Signing a petition	1	2	3
3	Attending a meeting	1	2	3

Card No. 1

			IF A "1" HAS BEEN CIRCLED ANYWHERE IN THE TABLE ABOVE, ASK THIS:
28.			Do you think this request has given or will give any results?
		1	Yes, has given
		2	Yes, might give
		3	No
		0	D.K.

I will now ask some questions about some sources of noise and air pollution that may exist in most cities.

		Have you noticed here at home during the last three months? Yes No D.K.	How often? Is it 1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	Would you say it has bothered you 1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	How often has it bothered you? Is it 1 almost everytime 2 about half the time 3 less often? 0 Don't know
Card 1					
Traffic noise	29-32	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
Aircraft noise	33-36	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
Noise from industries What industries?					
________	37-40	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
________	41-44	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
________	45-48	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
Other kinds of noise What noise?					
________	49-52	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
________	53-56	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
________	57-60	1 2 0	1 2 3 4 0	1 2 3 4 0	1 2 3 0

12.

		Have you noticed here at home during the last three months? Yes	 No	 D.K.	How often? Is it 1 every day 2 at least once a week 3 at least once a month 4 less often? 0 Don't know	Would you say it has bothered you 1 only a little 2 moderately 3 very much 4 not at all? 0 Don't know	How often has it bothered you? Is it 1 almost every time 2 about half the time 3 less often? 0 Don't know
Card 1							
Dust or soot from industries What industries?							
____________	61-64	1	2	0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
____________	65-68	1	2	0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
____________	69-72	1	2	0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
Card 2							
Odors from industries What industries?							
____________	1-4	1	2	0*	1 2 3 4 0	1 2 3 4* 0*	1 2 3 0
____________	5-8	1	2	0*	1 2 3 4 0	1 2 3 4* 0*	1 2 3 0
____________	9-12	1	2	0*	1 2 3 4 0	1 2 3 4* 0*	1 2 3 0
Other air pollution What air pollution?							
____________	17-20	1	2	0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
____________	21-24	1	2	0	1 2 3 4 0	1 2 3 4 0	1 2 3 0
____________	25-28	1	2	0	1 2 3 4 0	1 2 3 4 0	1 2 3 0

* GO TO QUESTION [illegible] AFTER COMPLETING THIS PAGE.

Card No. 2

50.			You said the odors have bothered you. Do you think it's better, worse, or the same this summer as last summer?
		1	better
	52	2	worse
	54	3	the same
	54	0	D.K.
51.			Do you think it's because there is less odor or because you have become used to it?
	54	1	less odor
	54	2	used to it
	54	0	D.K.
52.			Do you think it's because more odor or because you are more sensitive to it?
		1	more odor
		2	more sensitive
		0	D.K.
54.			Can you tell me about your general opinion about the problem of odor? Do you think that odors in general are
		1	very annoying
		2	annoying
		3	not too annoying
		4	not annoying at all?
		0	D.K.

Card No. 2

55.			Do you think you are
		1	more sensitive than other people to odor
		2	less sensitive than other people to odor
		3	or about the same?
		0	D.K.
56.			Do you think Carson has
		1	a greater problem with odor than other cities of its size
		2	a smaller problem with odor than other cities of its size
		3	about the same?
		0	D.K.
57.			We have also talked some about noise. Do you think noise in general is
		1	very annoying
		2	annoying
		3	not too annoying
		4	not annoying at all?
		0	D.K.

Card No. 2

58.			Do you think you are
		1	more sensitive than other people to noise
		2	less sensitive than other people to noise
		3	or about the same?
		0	D.K.
59.			Do you think Carson has
		1	a greater noise problem than other cities of its size
		2	a smaller noise problem than other cities of its size
		3	or about the same?
		0	D.K.
60.			Do you think the authorities are too much concerned about air pollution, too little concerned about air pollution, or as much concerned as they should be?
		1	Too much
		2	Too little
		3	As much
		0	D.K.
61.			Do you think the authorities are too much concerned about noise, or as much concerned as they should be?
		1	too much
		2	too little
		3	as much
		0	D.K.

Card No. 2

Respondent

62 Age 1   2   3   4   63 Marital 1 NM   2 M   3 W   4 D/S

			Husband		
Occupation	64	1 B.C.	2 W.C.	3 P.	
Industry	65				
Location	66	1	2	3	4
Education	67	1 E.S.	2 H.S.	3 C.E.	4 B.A.

			Wife		
Occupation	68	1 B.C.	2 W.C.	3 P.	
Industry	69				
Location	70	1	2	3	4
Education	71	1 E.S.	2 H.S.	3 C.E.	4 B.A.

Household Size										
Total No.	72	1	2	3	4	5	6	7	8	9+
No. of Children less than 6	73	1	2	3	4	5	6	7	8	9+
6-16	74	1	2	3	4	5	6	7	8	9+
Adults	75	1	2	3	4	5	6	7	8	9+

76 Sex 1 M. 2 F.

SECTION III

Use the actual wording of each question. Put X in appropriate square after each question. When in doubt record 'No'.

PREAMBLE I am going to ask you some questions, mainly about your chest. I should like you to answer 'YES' or 'NO' whenever possible.

Card 3

COUGH

1. Do you usually cough first thing in the morning [on getting up*]? 1 ☐ Yes 2 ☐ No — 1

Count a cough with first smoke or on first going out of doors. Exclude clearing throat or a single cough.

3. Do you usually cough during the day - or at night? 1 ☐ Yes 2 ☐ No — 2

Ignore an occasional cough.

If 'No' to both questions 1 and 3, go to question 6.

If 'Yes' to either question 1 or 3:

5. Do you cough like this on most days [or nights*] for as much as three months each year? 1 ☐ Yes 2 ☐ No 0 ☐ NA — 3

PHLEGM

6. Do you usually bring up any phlegm from your chest first thing in the morning [on getting up*]? 1 ☐ Yes 2 ☐ No — 4

Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.

8. Do you usually bring up any phlegm from your chest during the day - or at night? 1 ☐ Yes 2 ☐ No — 5

Accept twice or more.

If 'No' to both questions 6 and 8, go to question 12a.

If 'Yes' to either question 6 or 8:

10. Do you bring up phlegm like this on most days [or nights*] for as much as three months each year? 1 ☐ Yes 2 ☐ No 0 ☐ NA — 6

** For subjects who work at night.*

7

12a In the past three years have you had a period of [increased*] cough and phlegm lasting for three weeks or more? No ☐ 1

If 'No' to question 12a, go to question 13a

If 'Yes' to question 12a:

Yes-1 period ☐ 2

12b/c. Have you had more than one such period? Yes-2 or more periods ☐ 3

***** *For subjects who usually have phlegm.*

9

BREATHLESSNESS

14a. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? — Disabled † ☐ 1 — No-a. ☐ 2

If 'No' to question 14a, go to question 21

If 'Yes' to question 14a:

14b. Do you get short of breath walking with other people of your own age on level ground? — No-b. ☐ 3

If 'No' to question 14b, go to question 21

If 'Yes' to question 14b:

14c. Do you have to stop for breath when walking at your own pace on level ground? — No-c. ☐ 4 — Yes-c. ☐ 5

† Disabled from walking by any condition other than heart or lung disease.

CHEST ILLNESSES

21. During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? — No ☐ 1 — 16

If 'No' to question 21, go to question 22.

If 'Yes' to question 21:

21a. Did you bring up more phlegm than usual in any of these illnesses? — No ☐ 2

If 'No' to question 21a, go to question 22.

If 'Yes' to question 21a.

21b. How many illnesses like this have you had in the past three years? — 1 illness ☐ 3 — 2 or more illnesses ☐ 4

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22. Were you sick at any time last week or the week before? — Yes ☐ 1 — No ☐ 2 — 17

(**Week ends Sunday at midnight.**)

If 'Yes': What was the matter? ______________________________

____

Anything else? ______________________________

____

23. Have you been to a doctor within the last two weeks? ☐ ☐ 18

24. Have you been a patient in a hospital within the last two weeks? ☐ ☐ 19

25. I am going to read you a list of symptoms and I should like you to tell me whether you have each one frequently, occasionally or hardly ever.

How often do you have ________? Would you say you have it frequently, occasionally, or hardly ever?	Frequently	Occasionally	Hardly Ever Or Not At All	
Nervousness	1 ☐	2 ☐	3 ☐	33
Headache	1 ☐	2 ☐	3 ☐	34
Sleeplessness	1 ☐	2 ☐	3 ☐	35
Dizziness, nausea or vomiting	1 ☐	2 ☐	3 ☐	36
Constipitation	1 ☐	2 ☐	3 ☐	38
Pain in joints	1 ☐	2 ☐	3 ☐	39
Difficulty in urinating	1 ☐	2 ☐	3 ☐	40
Sinus congestion	1 ☐	2 ☐	3 ☐	42
Eye irritation	1 ☐	2 ☐	3 ☐	43
Burning or irritation of the nose	1 ☐	2 ☐	3 ☐	45
Runny nose	1 ☐	2 ☐	3 ☐	46
Chest pains	1 ☐	2 ☐	3 ☐	47

26. **Would you say that your health in general is**

Excellent	☐	(1)	48
Good	☐	(2)	
Fair	☐	(3)	
Poor?	☐	(4)	
Don't know	☐	(0)	

27. **Have you worked for a year or more in a dusty job?**

Yes	☐	(1)	49
No	☐	(2)	

Total number of years in dusty job? .... 50 ☐ 51 ☐

TOBACCO SMOKING

28. Do you smoke? ☐ Yes ☐ No

Record 'Yes' if regular smoker (as defined in question 29, up to one month ago.

If 'No' to question 28 ask question 29

If 'Yes' to question 28

Do you inhale the smoke? ☐ Yes ☐ No

Would you say you inhale the smoke slightly (S), moderately (M), deeply (D)? ☐ S ☐ M ☐ D

How old were you when you started smoking regularly? ____ years old

How many manufactured cigarettes do you usually smoke per day? ____ per working day ____ at weekends

How much tobacco (oz/g) do you usually smoke per week in hand-rolled cigarettes? __________

How much pipe tobacco (oz/g) do you usually smoke per week? __________

How many cigars do you usually smoke per week? __________

Specify large (L) or small (S).

29. Have you ever smoked as much as one cigarette a day [or one ounce of tobacco a month] for as long as a year? ☐ Yes ☐ No

If 'Yes' to question 29

How old were you when you started smoking regularly? ____ years old

How old were you when you last gave up smoking? ____ years old

How many manufactured cigarettes per day were you smoking before you gave up? ____ per working day ____ at weekends

How much tobacco (oz/g) per week were you smoking in hand-rolled cigarettes before you gave up? __________

How much pipe tobacco (oz/g) per week were you smoking before you gave up? __________

How many cigars per week were you smoking before you gave up? __________

Specify large (L) or small (S).

CODING FOR SMOKING HISTORY

Before coding refer to instructions.

Smoking history

Never smoked ☐ 1 52
Ex-smoker ☐ 2
Present smoker - does not inhale ☐ 3
Present smoker - inhales slightly ☐ 4
Present smoker - inhales moderately ☐ 5
Present smoker - inhales deeply ☐ 6

Type of smoker

Cigarettes only ☐ 1 53
Pipe only ☐ 2
Cigars only ☐ 3
Cigarettes and pipe/cigars ☐ 4
Cigars and pipe ☐ 5
Non-smoker ☐ 6

Amount smoked per day* (average including weekends)

Cigarette tobacco:
Nil ☐ 1 54
1-4 g ☐ 2
5-14 g ☐ 3
15-24 g ☐ 4
25-34 g ☐ 5
35 g or more ☐ 6

Pipe/cigar tobacco:
Nil ☐ 1 55
1-4 g ☐ 2
5-14 g ☐ 3
15-24 g ☐ 4
25-34 g ☐ 5
35 g or more ☐ 6

** 1 oz of pipe tobacco = 28 cigarettes = 28 g*
1 small cigar = 2 cigarettes
1 large cigar = 5 cigarettes

Age started (years) Code 00 if a non-smoker 56 ☐ 57 ☐

Age stopped (years) Code 00 if a present smoker 58 ☐ 59 ☐